NASA JOHNSON SPACE CENTER ORAL HISTORY PROJECT
ORAL HISTORY TRANSCRIPT

ROBERT J. WREN
INTERVIEWED BY JENNIFER ROSS-NAZZAL
HOUSTON, TEXAS – 16 OCTOBER 2007

ROSS-NAZZAL: Today is October 16th, 2007. This oral history with Bob Wren is being conducted for the Johnson Space Center Oral History Project in Houston, Texas. Jennifer Ross-Nazzal is the interviewer, and she is assisted by Rebecca Wright. Thanks again for joining us this morning. We appreciate it. I'd like to begin by asking you about your interest in engineering and spaceflight before you began working for NASA.

WREN: Okay. Thank you very much, and I'm happy to be here. I guess my interest in engineering started with my dad, who had gone two years to [Southwest Texas State Teachers College] San Marcos [Texas] and got a teaching certificate. And he was going to go to [Texas] A&M [College Station, Texas] but he couldn't make it, because he had to support the family. So all when I was growing up he wanted me to become an engineer and go to A&M to do so. I did become an engineer. But unfortunately I went to University of Texas [Austin, Texas], and not A&M. (laughter)

ROSS-NAZZAL: Ooh, sparking bad blood.

WREN: For him anyway. So that's how I got introduced to engineering. I went to school at UT, and then when I graduated there I interviewed several aerospace companies around the country. Republic and McDonnell in St. Louis [Missouri] and Boeing and so on and so forth. Anyway I

ended up with General Dynamics [GD], Fort Worth [Texas] working on the B-58 Hustler Bomber. I was there for I guess five and a half, six years. Started associate engineer and then became a test engineer. I can go into what I did there.

I guess the advantage to me of working at the bomber plant before I came to NASA -- now I'll get to NASA I guess in a little bit -- was that at the bomber plant I learned how to design and manufacture and test and operate an aircraft. What it took to do that. We had an assembly plant there that was vintage of World War II turning out World War II bombers. In one end of the plant would go some raw materials and out the other end would come a finished airplane. Inside was like a city and there was traffic lights and streets and all kinds of things.

So I learned how you could take materials and fabricate those, design those, and put them together to make an operating vehicle that would function to achieve some kind of purpose. In this case it was a fighter-bomber. But I learned how to do all those things and learned how the designs worked, how the designs had to go with kind of materials and the manufacturing and fabrication capability that existed. And then once you fabricated it and put it together how you verified your design through testing as well as your analyses. I was on the drawing board when I first got there to learn the drafting room manual standard criteria for the company on how to do drawings and so forth.

Worked a little while in the design group and then was sent out to the test lab, which was very fortunate for me, because there I got to get my hands on the hardware, which would serve me well later at NASA. So I got to static test and dynamic test, vibration test, acoustic test -- aircraft parts and hardware. And some upper stage spacecraft parts, because General Dynamics also had worked at San Diego [California] with the Centaur and Atlas stages and we did some of that test work at Fort Worth. So I was kind of familiar with some of the spacecraft hardware as

well. And we did some work on the B-57 and some other ones. But the main plane was the B-58 Hustler.

It was a honeycomb structure. Had a lot of advances to it. It was state-of-the-art. It had Coke-bottle shape for aerodynamic purposes so it could go supersonic with relative ease. Like I said, the structure was bonded honeycomb. It was fly-by-wire. Had a lot of advanced avionics. The airplane had an external pod stores, instead of a bomb bay. It was designed to have replaceable and interchangeable external pods.

Some of these pods would be fuel pods that would stay with the aircraft. Some would be reconnaissance pods that stayed with the aircraft. Some then you could throw off and jettison. Those could be just drop pods with munitions or they could be propulsion pods. Once you dropped one they'd fly. The idea, ultimate idea, was that you'd go in over the adversary--subsonic--and then when you got close, why, you'd accelerate supersonic, you'd jettison your pod, which would have a nuclear device on it, you'd do a maneuver and pitch out, roll over and get out of Dodge as fast as you could go. (Laughter) You were going top speed at that point to vacate the area.

The airplane itself was a delta wing. And so it handled much like the delta wing fighters that the company was making, which was F-102s and F-106s. It was more like a fighter plane than a bomber. When we turned it over to the Air Force across the field at Carswell [Air Force Base, Texas] for example, they were having some difficulty flying it and lost some crews, because what they did is they put multiengine pilots on it that were used to flying multiengine bombers. This is multiengine, four engines okay, but for example it took off and landed at a high angle of attack, because of the delta wing, more like a fighter than a bomber. So we convinced

the Air Force to put fighter pilots on the crew. That pretty much solved the problem. They could handle that.

Now big thing there that was different than when I got to NASA was it was an airplane, and we were very concerned in the structures area about cyclic fatigue because the airplane had to last so many years and so many cycles of usage and life. So we did a lot of cyclic fatigue testing in addition to static strength testing. We used whiffletrees and all kinds of devices to pull and tug on the different parts of the airplane. We would start with components and work up to subassemblies, assemblies, and finally the complete airplane. We did cyclic fatigue tests like for example on the wing. We did the same thing on the empennage, the vertical tail, and on the main landing gear, the nose gear. Finally we did it on a complete airplane, Airplane 29. So I was heavily involved in all that and learned quite a bit.

I also had a little side project going on the side. I was kind of interested in magnetohydrodynamics. And so I had a little jury-rigged outfit over at the corner outside behind the building where I was trying to develop, or expand upon, a capability to use magnetics. A magnetic bottle to contain high temperatures. Where the temperature of the plasma for whatever use, either for arc jets or for propulsion, ion propulsion, was so high that we didn't have any materials that could contain the temperature involved. So I kind of messed with that. Later on, why, we had an arc jet here at NASA that we used, very very similar. We also have a lot of folks working on ion engines, which use the same basic principles. So I guess that's kind of what I did and started up at the bomber plant. Of course while I was there I went to school in the evening over at Dallas [Texas] at SMU [Southern Methodist University]. Worked on my master's, which I finally got.

[Some of the people I worked with at GD: Henry Growald, Glenn Robinson, Haskell Nolan, Weldon Walker, Fred Cox, Charlie Archer, John Maulden, Bob Adel, Dick Schmiegel, Gene Varner, Phil Haught, Jim Bonner, John Lacey, Joe Bateman, Sam Glorioso, R.L. Johnston, R.E. Johnson. All that I can remember.]

We did a lot of tennis playing and a lot of waterskiing. There was a lake right next door. (Laughter) And my roommate and I would go out there in the afternoon and then we had kind of taken over the slalom course that somebody had there. So we started conducting classes and teaching water skiing. We had the jump and the slalom course and so forth. We just had a lot of fun with that.

[My son, Pat, said I should mix in some funny stories to liven things up a bit.] My roommate had two airplanes. He had a little T-craft, fabric-covered, that we used for proficiency training. And then he had a cross-country aircraft, a Cessna 180 that we flew to University of Texas Longhorn football games. So we'd go cross-country in that. But I guess one funny story is that we were going to do an overhaul on the T-craft and one of the compadres that worked with us was assigned to go to San Diego's GD plant for a year, so he loaded up his wife and his family and away they went. So we were to babysit his house for him, kind of look after it. So came time to do this overhaul, and so we found a kid's swing set that would make a perfect A-frame to hold the engine up when we took it out. We took the parts apart. We had the wing -- because you have to fabric-cover it, it's a lot of dope and paint. We had the wing in the hallway and the parts all over the house. Everything was going well. We were making good progress. All of a sudden we get a phone call. They're coming home early. So there was a mad rush to get all those parts out of that lady's house, but we made it. (laughter)

ROSS-NAZZAL: Oh good. They ever find out that you were doing that?

WREN: No, no, they never did. They may know now. Fred Cox was my roommate then. We scuba dived some. Nobody knew anything about scuba diving back in those days. So Fred and I went out to -- and Fred had gone to UT also. Was a good Longhorn. Fred and I went out to Possum Kingdom Lake and we found a dive shop with a double-hose regulator and just went and went diving. Of course there weren't any certificates, you know. It's lucky we're still here today. But we did it anyway. [I also spent a lot of time with my son, Jamie, at Six Flags during the summers. Practically lived at that place, especially Skull Island and the Old West Shoot Out area.]

ROSS-NAZZAL: When did you start working at GD?

WREN: This was in -- see, I graduated from UT in -- believe it was August of '56. I entered graduate school there at Austin to work on my master's. And so I had been working with the Bureau of Reclamation to work my way through school. I had many jobs. But the latest one at that time was with the Area Planning Office of the Bureau of Reclamation there in Austin. So I had been working part-time. So when I graduated I started working full-time and going to school part-time on my master's at UT. I went a semester and about a half I guess. In the spring of '57, I left there and went to General Dynamics. So that was the spring of '57. Then transferred everything to SMU so I could continue my studies there.

ROSS-NAZZAL: So you were there when Sputnik went up. What are your recollections of Sputnik?

WREN: Wow! It was pretty exciting. I got real interested in space while I was still -- naturally when I got to GD I got interested in space in addition to airplanes. The way I got interested in space, aside from Sputnik and Telstar and all those wonderful things that went up, is that the company had seminars set up with Space Technology Laboratories, STL. Which by the way Joe [Joseph F.] Shea was with at one time, who I later worked with. They had a whole series of seminars on what folks had done in trying to come up with the ways of operating in space for trajectory analysis, throw weights, how you build this and that. And the micrometeoroid environment. On and on and on.

So I dove into that stuff and studied it like crazy. Here I am at the bomber plant and I'm getting more and more pumped up about space work. So that's kind of how that happened. Of course also at that time, why, [Wernher] von Braun had written a book about going to Mars. A lot of us had read that. So we were all excited about going to space.

ROSS-NAZZAL: And so when you heard that they were going to be building a space laboratory down here did you jump at that opportunity?

WREN: Well, what happened there was that the Space Task Group -- I'll switch now. The Space Task Group up in Virginia do fantastic work. Can say nothing but good things about the old NACA, National Advisory Committee for Aeronautics, and the Space Task Group in particular. A lot of my good friends through the years and still good friends to this day had their roots in the

Space Task Group at Langley [Research Center, Hampton, Virginia]. Well, when NASA was created in the Space Act of 1958, they started putting together the organization, and then finally it was determined to move it to Houston, it was very apparent that they were not going to have enough people to do the Gemini Project, and certainly the Apollo Project. So although the Space Task Group was all bright people, there weren't enough of them. So what they decided to do was to go out to industry and try to find some people to bring in to help them.

That's what happened in my case. People came looking for folks to come on down and join the new NASA group. Aleck [C.] Bond I guess hired me and Max [Maxime A.] Faget. Anyway they came to GD looking for people and interviewed me and decided I might have something to offer. So brought me down. They wanted me down in the spring of '62. I couldn't make it because I said look, I'm just this close for getting my master's at SMU, and I'll finish up in August. "Oh, I've got to have you right now."

I said, "Well, I don't know, I want to come, but I want that master's."

So anyway it turned out that I was allowed to finish. And that's how I got my master's. I came down in August of '62. When I first arrived of course I was located in the Rich Fan Building on Telephone Road. [I distinctly remember one of the many fine people I immediately came to know was Alfred J. "Al" Ligrani. Such a kind and capable gentleman that I am proud to say is still a friend to this day. And we are both in the Space Center Rotary Club. The same goes for Jack R. Lister.] We were scattered all up and down Telephone Road with the temporary buildings. I can't remember them all but Farnsworth/Chambers is where we had a kind of a headquarters. We had the Rich Building, and we had Engineering in the Rich Building. ASPO, Apollo Spacecraft Program Office I think was located there. We had Franklin Apartments, Lane

Wells, East End State Bank. We were all over the place in different groups in different places. So that's where I started out.

You might help me. I was trying to remember. Was there anything exciting that happened in the Rich Building per se? It was an old fan manufacturing building. So it had offices over on the side and upstairs, there was a couple of levels. And it had a big old open bay area where they had manufactured fans I guess. So we set up some equipment in there for vibration and static test and so forth. But it was minimal because we knew we were going to go down to the site that was under construction. But I remember there was a day when JFK [President John F. Kennedy] came by and came through Rich Building. I can't remember exactly when it was and why he was there, other than just checking on how the space program was going. I can't remember if that was in conjunction with him going over to Rice [University, Houston, Texas] to make a speech at Rice Stadium or not. You might be able to help me with that. I can't remember the dates. But I do remember JFK. And somebody said, "Hey JFK's in the building."

I said, "Oh."

I was busy working hard. So I went downstairs and went over there and saw him. He walked by. Shook his hand and all that. But I was so involved in the challenge of trying to do what I was charged with doing that I didn't care too much about it. But now that I think back that was kind of silly. I mean here's this -- quite a man. Anyway he came through the building and it was pretty nice that he would actually take time to show up and see what we were up to. And trying to meet his request to put a man on the Moon before the end of the decade.

ROSS-NAZZAL: Why don't you tell us a little bit more about the Rich Building. I understand that Aleck Bond had put other laboratories and other type of facilities in there besides the vibration testing lab.

WREN: I think so. And I don't remember all that. So I probably can't help a whole lot with that. I don't remember what all was there. Like I said, I think we had some static test machines there, like Instrons and so forth. As best I remember it was mainly maybe a few vibration shakers and some static test machines. I can't recall if we had any mockups activity going there or not. We might have had. I don't remember. One of the reasons I don't remember too much is I was doing a lot of traveling too.

ROSS-NAZZAL: Oh, you were?

WREN: Yes. See, what I was charged with -- and the reason why they kind of wanted me there, I guess -- is that Max and Aleck and Joe [Joseph N.] Kotanchik, [H.] Kurt Strass, those guys wanted somehow to be able to verify that the Apollo spacecraft could withstand the launch and boost environment for vibration and acoustics, as well as the traditional structural strength. We didn't care about cyclic fatigue now, because this is a spacecraft and not an airplane, so it's a one-shot deal, so you don't worry about cyclic fatigue.

But we had to figure out now how are we going to verify this. Remembering that we are in a big rush. The environment was hectic to say the least. We had a big job to do. Not quite sure how to do it. We had spacecraft to build, design, check out, verify, and fly. And we weren't quite sure how to do it. We had to do it in a big rush because we had to meet the decade

requirement. So and of course on the ops [operations] side of course we had all kinds of things to develop and create there. How do you control this beast and so forth and fly the mission once you've designed and built the hardware and put it in place and checked it out and verified it? Well, anyway one part of that was like I said the launch and boost.

So what we said was that well we can simulate the vibration. We kind of know how to do that. We've done that before. We've got the equipment to do that. So we'll create a laboratory to enable us to do that. But that's pretty straightforward.

But the one that had us was the acoustics. Where in the world does acoustics come from? Well, it comes from a couple of sources. One is the low-frequency sound waves of immense magnitude, amplitude that come from the firing of the first-stage engine at the launch pad. At that time we were contemplating not only the S-I but the Saturn V. And I guess I need to say something about that.

The frequency of the sound wave that the spacecraft and the crew would see is a function of the diameter of the exhaust nozzle, the bell. The bigger the nozzle, the lower the frequency. Well, the size of the nozzle of the F1 engine on the Saturn V is humongous. I don't remember the exact feet or meters or whatever. But it was big. So what did that mean?

What that meant was that the sound coming out of the exhaust that would radiate and come back up to the spacecraft was very very high-level at very low frequency. So we had to figure out a way to simulate all that and be sure that our spacecraft would withstand it; the structure of it, all the components, and of course the crew. The second source of sound came from when we accelerated off the pad and we went through what we call -- we go supersonic. We go through Max Q or maximum dynamic pressure. We get a series of shockwaves that pass by the payload if you like. In this case the payload is the Apollo Command/Service Module and

LM [Lunar Module]. And we also get a lot of the turbulence that goes by, very similar to what you get in an airplane cockpit, fighter cockpit, at very high amplitude in the middle frequencies. This is why a lot of the guys that fly jets have a notch in their hearing at the mid frequency range because of that noise going around the cockpit.

But anyway, so we were charged with trying to figure out a way to simulate all that and do it in a hurry. So what I did was I didn't know a whole lot about acoustics at that point. I'd been working in a lot of other areas. I decided I'd better learn in a hurry so I found out that the top acoustics people in the country were at MIT [Massachusetts Institute of Technology, Cambridge, Massachusetts]. There was some professors there who also had set up a consulting arrangement on the side, Bolt, Beranek and Newman [BBN]. I went and paid them a visit and said hey, we need help. Here's what we need. They said gee that'd be fine, we'd be happy to help you. And says matter of fact Leo [L.] Beranek's daughter married a fellow by the name of Ken [Kenneth McK.] Eldred.

Ken Eldred was director of research with Wyle Labs, also located in Boston [Massachusetts] and El Segundo [California]. So they plugged me in to Ken. And all that was wonderful. That saved the day. Because Ken Eldred's one of the smartest people I've ever had the pleasure of knowing and working with, but at the same time that he could do his very deep detailed technical work, he had the ability to convey that to idiots like me, the laypeople, so we could understand it as he went through all of his equations. I made the best use of Ken Eldred and the Wyle Research Group as well as BBN and MIT to try to solve these problems. That's why I took a long time to explain why I wasn't in the Rich Building much, because I was traveling to El Segundo and Boston and so forth, trying to figure out how to simulate those environments in a ground test for Apollo.

I don't know how we did all this. The task of trying to create the spacecraft that I've been talking about, at the same time we were trying to create the laboratories for longtime use as well as specifically for Apollo and perhaps Gemini. So we were trying to design and create facilities. So in the process of that and these studies that we were doing with Ken Eldred and Wyle, we created what we called Building 49 on site back in the back, which is the VATF or Vibration and Acoustic Test Facility.

It looks kind of funny when you see it because it's some low buildings and then a couple of towers. Well my goodness, what are those towers for? Well, the reason for that was the low buildings were obvious, we had a general vibration laboratory in part of it and some low-level small component acoustic test capability, little chambers in the other parts of it. We put the static test back up in Building 13 with Jim [James] McBride, so we didn't have to fool with that. Jim [and Richard W. "Dick" Bricker] more than adequately handled all that. But at 49 then we had the general vibration laboratory and general kind of acoustic lab. But for the big pieces when we actually had the Apollo spacecraft in there it's pretty tall. We wanted to do the testing in the vertical position.

So we created the towers, two of them. We had one for vibration. We could put the vehicle in there and put it on shakers and shake it free free mode or we could tie the end down and do a fixed-base mode, depending upon what kind of test conditions you were utilizing. Then we had the other tower where we were going to put great big old acoustic horns in there, like your speakers for your hi-fi or your stereo equipment. But these were huge, huge drivers. So we created all that and we created a sleeve, finally came up with kind of a sleeve arrangement to come over the top of the CSM [Command and Service Module]. We put the drivers up on top

and drove the high-level high-amplitude sound down around the vehicle is how we solved that problem. It was a sight to see, and it was a lot of racket.

One funny story -- I'll throw in a couple funny stories here, it's getting kind of boring I guess. One of the funny stories is that we created the driver -- we had to have huge drivers. When I say driver, when you have a speaker you've got coils and so forth to drive the cone you know and make the noise. So the noise come out -- or sound. By the way in acoustics -- I learned a lot about acoustics -- if it's pleasant that you like to hear, why, then it's sound. If it's unwanted sound it's called noise. (Laughter) But it's all the same thing. It's amplitude, wave amplitude of energy going through the air.

So anyway we had these drivers that Wyle created for us up at their Huntsville [Alabama] location. The fellow that worked for Ken Eldred named Fancher [M.] Murray had this thing all fixed up, and they tested it out up there, and it was ready to ship it down to us and install it in our test rig. So we were in a big rush. So they couldn't get the shipping arranged quick enough. I mean we're working round the clock 24/7. We said oh we got to have those drivers down here, those speaker drivers. So Fancher says that's okay, I'll put it in my car and I'll drive it down there.

So they loaded this thing in the back end of his sedan, big old Lincoln, and he comes driving across country right through the middle of the night down from Huntsville. Well he got down somewhere in Louisiana and he got pulled over by the gendarmes. (Laughter) Because his vehicle's going down the road with the tail dragging almost on the pavement, and they thought sure that he was you know a rumrunner or something, you know, had a still, and so they made him open up the trunk and they looked in there and they didn't understand the mess that was in there. Said, "What kind of still is that?" They thought he had a liquor still. But it finally

got straightened out with a few phone calls and we got him released there and got him on down the way, delivering his drivers.

Anyway the test went pretty well. I had another interesting story. It's kind of a sidelight, but at the time there was a lot of tie with the original astronaut crew, the seven, with Hollywood and the entertainers and Jose Jimenez and so on and so forth. Well they kind of continued in that vein and they were making a movie -- they always seemed to be making movies on site. They were making a movie with -- I think it was called *The [Reluctant] Astronaut*. It had -- oh what was that fellow's name? Time out. I've got to find his name. Don Knotts.

Don Knotts, and he'd been on the television and movies and so forth, and he was kind of -- he played a goofy guy, kind of a goofy persona. Well he was on site and they're making this movie. He asked to go see some of the labs and so forth so he'd get a better feel to help him play his role in the movie. So they called me up and said hey can he come out and see the VATF and I said sure that's okay. So he came out in the middle of the night, and of course we were out there all hours of the night. I took him around and showed him this and that. And took him way up the towers and so forth. What was really funny to me was that here was this goofy guy, funny guy, and talking in person he was more like his real self. He was very cogent, very intelligent, he asked a lot of good questions, he was very interested in the details of what we were doing and why we were doing it; I was amazed. My God, that's the guy from the television. (Laughter) But that was a very pleasant surprise that he was so like that, yeah.

ROSS-NAZZAL: Yes, he wasn't like his [Barnie Fife] character.

WREN: Right, his [Barnie Fife], right.

ROSS-NAZZAL: That's funny.

WREN: Right.

ROSS-NAZZAL: Let me ask you a couple questions about the Vibration and Acoustic Test Facility. You mentioned that the acoustics was going to be a major issue, but were there vibration test facilities across the country that you might have considered testing the Apollo Command Module and things in?

WREN: Yes. As a matter of fact, we did take some parts of the Command/Service Module out to an acoustic chamber that Ken had in El Segundo. We made use of that. I can't recall the details now on how big it was but it was of sufficient size to test the component or subassembly or assembly that we were testing at the time. That was an acoustic test. Some vibration tests might have been done at Downey [California], I don't recall. But we did most of it there in 49 in our general vibration lab. Then when we got the whole what we called boilerplate structures where you have mass simulators instead of actual systems we did most of that in the vibration tower or in the general vibration lab depending upon what size we were dealing with and so forth and what the test conditions were. But we did all that in 49, yes.

ROSS-NAZZAL: How did your facilities differ from say the facilities out at North American [Aviation] or in El Segundo?

WREN: Well, the general vibration lab was probably about the same. We may or may not have had more equipment. But they didn't have a tower like we created where we could put the whole stack up there and shake it in one unit and push on it and do bad things to it and try to tear it apart and so forth. And of course all the time making engineering measurements and so forth on strains and stresses and accelerations and so on and so forth. They didn't have that kind of capability.

So that was unique that we could put the whole vertical stack in there and shake it and work on it, push on it, be mean to it, try to get it to break, as well as see what its response behavior characteristics were. And the same thing with the acoustic. Nobody had a capability to test the entire stack. So that's why we created that tower and had the big drivers that I was talking about, acoustic drivers, and the great big huge kind of like enveloping horn things that we encapsulated the spacecraft with these horns and drove the noise down through the horns.

In other words, in effect I guess you'd say that we put the spacecraft up in the throat of a big old speaker, kind of is what we did. [Total, I believe, of 160,000 watts of power.] Nobody had that capability, because this was a big vehicle, you know. We had the Command/Service Module and the SLA in there, Spacecraft LM Adapter. So it's pretty high stack in there.

ROSS-NAZZAL: Did you do any work with Brown and Root?

WREN: Brown and Root, their role was -- everybody had roles, bless their hearts, but Brown and Root had the facility operations contract, or one of them, and with the Engineering Directorate. And so the Brown and Root folks, Pete Gist and Bruce [R. Vernier] supported the space chambers, SESL (Space Environment Simulation Laboratory) Building 32, and then VATF in

Building 49, and also the general [structural] lab in Building 13, and a few others: [Robert H. "Bob" Jeffries, Stephen M. Suarez, etc]. So that's where the Brown and Root-Northrop came from or BRN, and it was a combined merger of Brown and Root, the construction company, and Northrop Aviation. I think Pete had come from Brown and Root and Bruce came from Northrop. I'm not sure but that's the BRN people or Brown and Root-Northrop people. So they operated the facilities for us. They had some lead engineers and so forth as well as their management. And then a whole bevy of technicians to actually operate the equipment for us.

In essence on the civil service side we didn't have any technicians operating equipment. We depended upon the contract folks to do that for us. We had engineers but we didn't have technicians. I think we had one lead technician to kind of oversee things but beyond that it was Brown and Root-Northrop technicians.

ROSS-NAZZAL: Did you decide where to place the VATF on the Center site itself?

WREN: No, I don't recall who decided to put it back there at the corner across from the water tower where it's located. I don't recall. It was probably just part of the facility layout. The facilities folks were wonderful. They were going hard trying to create all this infrastructure. You know there's a tunnel system that goes underneath the site? A lot of people don't know that.

ROSS-NAZZAL: I did not know that.

WREN: There is an entire tunnel system underneath the site over here. It was put in place -- and the tunnel system's big enough you can walk in it. Most folks don't know it's there and fewer people have ever been in it. I've been in it all over the whole thing.

Why is it there? It was put there so that you could have a central cooling and heating plant for one thing. Then you could send all of your heating and cooling pipes all over the Center to all the different facilities and buildings and not have to repeat that in every building. So there's a big old heating and cooling plant building over there that's at the apex or source of the tunnel supply system. The other reason for the tunnel is that we have all kinds of cables running under there. All of the electrical power to operate the site, building lights and so forth are all underground. They all go in that tunnel. The other reason is for communication. Everything's underground. There's no telephone wires overhead or anything. They're all running underground in those things. Then communication same thing. Communication and data-handling and so forth, they're all running through that series of tunnels under there. So we could hook up things in for example Building 49 VATF and communicate with the SESL, with Building 13, all over the place. So that's all down there.

ROSS-NAZZAL: Interesting. I had no idea.

WREN: Yes, and every once in a while you get a clue -- now that you know it's there -- if you drive around the site every once in a while you'll see a little thing kind of sticks up and it's got some vents on the side of it, little holes with you know spaces there and maybe a manhole cover or something up on top. What that is is ventilation so you can get air down into the tunnels.

ROSS-NAZZAL: I'll have to go look next time I'm on site. So when did the Vibration and Acoustic Test Facility officially open?

WREN: Ooh, see, I'm going to refer to a note here. I know I remember I left the Rich Building and was headed for the site for 49, and 49 wasn't ready yet. I can't remember the exact time. I had to go to Ellington [Field, Houston, Texas] for a few months while we were waiting for 49 Office Building to finish. When we finally got down there, golly, it was probably about '63 or [6]4, somewhere in there. I'm guessing.

ROSS-NAZZAL: What did you guys have to do to get the building ready? What sort of testing did you have to do to prove that it was ready to work on the Apollo program?

WREN: Oh, okay, well the things like shaker equipment, that was pretty straightforward because that was off-the-shelf equipment that we purchased from Ling and different manufacturers. Ling was a big manufacturer of shaker equipment at the time. Of course when you have those kinds of things you have controls for the shakers. You have instrumentation to measure responses of the specimen you're testing. So we had big banks of control equipment and instrumentation equipment. So part of the checkout would be to put the forcing function, either the shakers or hydraulic pistons or whatever we were using to impart the force, in place and put it maybe on some kind of dummy something or other, and then hook the whole mess up and see if it would behave like it was supposed to to deliver the force and excitations and also that the instrumentation paths were all good and we were getting measurements and they were being processed okay and recorded on the tape recorders and the oscillographs or whatever we had and

so forth. So all of that laboratory kind of equipment had to be put in place and then checked out and deemed to be operational. Before we actually put real specimens in for test.

ROSS-NAZZAL: Were there any challenges that you faced while you were working on that?

WREN: Not so much on the vibration side, because that was fairly straightforward, like I said. But on the acoustic side is where we really had the challenges. Nobody had created speaker drivers of the size, immensity, of what we needed to get the kind of sound pressure levels that we needed to achieve and at the frequency ranges that we needed it. So to hook all that up was quite an effort. I can't recall whether we put a boilerplate, we must have, of some kind in to check out our shrouds and our drivers. I guess we did that and I'm sure we did, we must have, because it's logical that we would have done that so we'd have a mold line to fit our speakers around and be sure they all worked okay, and then take them back off and put them on the real vehicle. We must have done that.

ROSS-NAZZAL: Did you do any testing of Gemini hardware? Or was this just for Apollo?

WREN: The way that worked was that you know McDonnell had the contract for Gemini. Gemini was kind of run independently of Apollo and what we were trying to do on site. So almost everything that was entailed in the Gemini Project was done at McDonnell or at the Cape [Canaveral, Florida]. So we didn't have a whole lot of involvement in that. However, from time to time since we had the equipment there they would call us up and say hey can you test blah blah blah chunks of equipment. So they would send it to us and we would test that. So that's

how we were involved in Gemini, with some help out kind of efforts on some of the vibration tests and maybe some of the acoustic, I don't recall. But that was the mode.

The reason for that was more big picture kind of thing, was that the management wanted to keep the Gemini program separate from Apollo because Apollo was such a challenge that it wanted to kind of keep them going. We had to go in parallel. Why did we have to go in parallel? Well because a lot of the forcing functions for the Apollo designs depended upon answers we would get from Gemini. In other words we used Gemini, which is a big old Mercury, to check out rendezvous capabilities and docking capabilities and so on and so forth. These techniques and approaches then would lead to our requirements that we needed in the design of the Apollo hardware. So that's why we were running those things in parallel. And Chuck [Charles W.] Matthews and Jim [James A.] Chamberlin and some of the guys were doing the Gemini Project, mainly like I said working with the people in St. Louis at McDonnell. But that was our involvement at that lab, was just on a piecemeal basis.

ROSS-NAZZAL: What do you think that you learned from doing this task that you applied to the rest of your career at NASA?

WREN: Well, for one thing I learned how to work hard and get no sleep. (Laughter) We were going -- like I keep saying and I'm sorry to beat that rabbit over and over, but we were working 24/7 around the clock. Now the good part was that we were all young. We were in our 20s and 30s. We wore short-sleeved white shirts with narrow black ties and crew cuts, flattops, and we were gung-ho and enthusiastic. Another funny one is that a lot of us were single in those early days, and we'd work round the clock and round the clock, and we just couldn't take it any longer.

And so we'd jump on an airplane and we'd go down to Acapulco [Mexico] for two, three days and just party. (Laughter)

ROSS-NAZZAL: And not get any more sleep?

WREN: Right, right. Still not get any sleep, right. Well at least we had something else going on and lots of laughs and fun. Then we'd come back. I got stories about flying Pan Am and Aeronaves de Mexico down there, but that's probably another time. But anyway so that was a relief for us so we could get back and then hit it again 24/7. But we were working long and hard and going fast. So we didn't have a whole lot of time to do a lot of breathing. Plus doing our traveling like I said, you know, for creating approaches for the simulations, and then of course also helping with the actual hardware, flight hardware. I practically lived in Downey, like a lot of us did. And then later on Bethpage [New York], when we were working with Grumman to be involved intimately with the design and creation, fabrication and test and verification of the space hardware.

ROSS-NAZZAL: Let me ask you a few things about your social life. You mentioned a lot of you were single at that point. Were you still single at that point?

WREN: Yes. Yes. Yes. Yes.

ROSS-NAZZAL: Were you living here in the Clear Lake [Texas] area or did you live elsewhere?

WREN: Well yes when I first came down from Fort Worth and Dallas I was single at that time. As a matter of fact we were in a located up and down Telephone Road, so most of us lived in that area. So there was a guy, [Duke Mitchum], I had run into over at Love Field [Dallas, Texas] at a party after school one night there who was a reservations manager with Tree Top Airlines, or Trans-Texas Airways. We called them Tree Top Airlines. (Laughter) Later became I guess what? TIA, Trans International Airways or something. Anyway he was reservations manager for the company in Dallas and he was going to become reservations manager in Houston, so he said, "Hey why don't we room together, I'm going down there." So we did. So we got an apartment on Telephone Road, in the I think it was the Skylane Apartments or something. Just lived there, two of us for a while. Then later on we went our separate ways. But yes I lived on Telephone Road.

ROSS-NAZZAL: And when you moved, did you move to the Clear Lake area? Or did you move--?

WREN: I kind of stayed up that way when we came down to the site. Golly, I can't remember where all I lived. Apartment living, you know, single guys lives in apartments and so forth. I always just tried to keep busy. I entered myself in the Ph.D. program at University of Houston [Houston, Texas]. So I was taking some classes and teaching some also over on the main campus there. So it was beneficial for me to kind of stay close there as against go ahead and move right away down to the Clear Lake area. So I kind of stayed in that vicinity. I can't remember where all I lived, but somewhere around between Telephone Road and U of H, in that vicinity.

ROSS-NAZZAL: What did you think of Houston when you moved here?

WREN: Just another city, it was a nice city. But I mean I'd just come from Dallas/Fort Worth and they had a little rivalry going. And of course I remembered Houston from being up at Austin at University of Texas. Texas would come down to play Rice, and Jess Neely's Rice Owls would always whip us. We could not beat Rice. (Laughter)

ROSS-NAZZAL: I would think it'd be the other way around.

WREN: Well it came the other way around later on, when Darrell [K.] Royal showed up at University of Texas. But in those days we had Ed Price, and he didn't do us too well. So we kept coming down to Rice games and go away with oh well we had fun. But we didn't win but we had fun. So but no, Houston was a fine place. It's grown a lot. I mean it was pretty small back in those days.

Of course down here at the site, why, it was just a ranch. Wasn't anything here. So I think it was what belonged to -- how did that work? Belonged to Exxon I guess. Humble Oil and Refining Company. They were going to donate it to the government for the site but they couldn't do it, couldn't give it because they were a private company. So they gave it to Rice and Rice then turned around and could deed it and give it to the government because they were a university, I think is the way it went. But anyway it was all part of Jim West's big ranch.

ROSS-NAZZAL: You mentioned some of the other tasks that you were working on was traveling to Downey and then later to Bethpage to work with them on the LM. What would you do when you were out at Downey? You mentioned working on the hardware and testing. Could you elaborate a bit more on that?

WREN: Yes. If it was test stuff it was mostly at El Segundo with Wyle, there by LAX [Los Angeles International Airport, Los Angeles, California] by the airport. You'd just go to their test site and witness the test that was done, be sure it was done properly and the proper procedures. Of course it was very elaborate procedures. When you're dealing with aircraft parts and spacecraft parts, it's all a controlled environment. So everything you do is controlled. You got process control, parts control, you're trying to maintain pedigree, so that no erroneous parts get into the vehicle or into the system or any bad parts get in, don't want any of those. So everything's controlled. So it gives rise to quite a bit of paperwork you need to keep track of all this process control.

The same thing applies to testing when you're doing a test. You got test controls and test procedures and very elaborate, and you go through it, and you want to adhere to whatever it is that you set out to do and what you set up. You pass all these things through and you set up a system of boards and reviews and so forth, so everybody gets a chance to have their oar in, to be sure that it's done the way it should be done and everybody's happy. You all agree to that and once you agree to it then you adhere to that system and those processes.

Same thing in the test part as well as the manufacturer, design manufacturer, is that you have elaborate TPSs, test procedure sheets, that you set up and you adhere to that. We actually set up just like in the design part of it. For tests we'd set up reviews, test readiness reviews. And

we'd have those. Everybody that's involved in it, they're all ready. Equipment's all ready. The specimen's ready, etc., etc. When you go out for a test, why, then you would as a NASA civil service person out there having a contractor run a test on a part, why, you'd be observant that they're following the proper procedures and so forth. And that the test is done properly so that it has a proper pedigree and quality with it so that when you get a result you know you can count on it and it was the right thing. So there's a lot of rigor that goes into controlling it. We kind of had little jests sometimes but there's a lot of serious control involved in that. But that's what I would do. Like, you know, if there was a test going out there. There were some tests done in Downey. But most of it was, that I was involved in, was in El Segundo I guess.

ROSS-NAZZAL: And when you flew out there did you fly on a NASA plane or did you just fly commercial?

WREN: (Laughter) No, we got to be regulars on the commercial planes out there. At the time it was, if I recall, it was Continental Airlines and National Airlines. The proud bird with the golden tail was Continental. We went at all hours of the day and night. So oftentimes we would catch the puddle-jumpers, what we called red eyes at night going both ways. If we were going to Downey if at all possible we'd try to time it with our flight so we wouldn't hit rush hour. Because rush hour out there on the freeways is, you know, it's gridlock. Of course we learned right away how to go up Imperial and Century Boulevard to get from LAX to Downey and not even go on the freeways. We could go zooming up. Finally got the lights timed pretty good, and you can get there pretty quick. But yes, that's the way we got out there.

So no, I never did -- now some of the upper management would fly, we had a couple of executive aircraft. And they would use those. But most of us would just fly commercial. And sometimes nonstop, hopefully, but a lot of times the puddle-jumpers, up and down, up and down. Four, five stops between here and there. But we didn't have a choice because we needed to get back one direction or the other in a big rush.

Now later on when we were doing a lot of work up at Huntsville, we had created a little short shuttle service that went from Ellington to Redstone Arsenal [Alabama]. We could fly that. It was a contract service. Used Lockheed Electras, I believe, turboprops, or Viscounts, I can't remember which now, or maybe both. You could go over and catch the flight in the morning at Ellington and then fly up to Redstone, take about an hour and a half or so, land and then they'd pick you up and take you over to wherever you were going, a lab or office building or whatever. To the von Braun Hilton or whatever. And do whatever you needed to do in the course of the day, and then they'd take you back over to Redstone Strip, and you'd catch the shuttle and come back. So point was you'd leave in the morning and take a commute all the way up 750 miles or whatever it is to Huntsville and do your daily work and then come back that night. (Laughter) So we did that for quite a while too. So anyway made use of that.

ROSS-NAZZAL: That's not bad. The VATF, once you had it operational, did you ever make any changes to that facility?

WREN: No, I don't think we -- other than state-of-the-art updates that we thought ahead far enough that we had everything pretty much in place. We had a whole area for the control and instrumentation equipment and we had -- as a typical computer setup, we had false floors with

cooling for all the equipment going underneath the floor and all that sort of thing like you'd have in -- this was long before, remember now, desktop computers. You have huge computers, you know, and so you had to have cooling because they put out a lot of heat. And of course you ran all your wire bundles underneath the floor that way and you have wire trays and so forth to run all the control and instrumentation wiring and equipment underneath the floors.

That's kind of a funny -- when I was still at the bomber plant we were trying to run a test up there. All of a sudden half the power in the whole lab out there went down, and the control equipment wouldn't work. Everything went phooey and it took about a half a day to a day in semidarkness to finally find the problem. The problem was a squirrel. A squirrel had gotten inside the building and gotten into one of those wire trays and gnawed through and caused short circuits. (Laughter) And shut the whole place down. A squirrel. Anyway I don't know why I thought of that.

ROSS-NAZZAL: Darn rodents.

WREN: Right.

ROSS-NAZZAL: You mentioned using the big mainframe computers. What other type of equipment did you use to do your job in the early '60s?

WREN: I can remember that on the desk we had electric calculators. Of course some of us were still clinging to the slide rule days, and we had our circular slide rules. Hardly anybody had the long hanging slide rules anymore but certainly had electric calculators, Fridens and Marchants

and so forth, that sat on top of the table, and you'd key in your calculations that you wanted to put in there, and then push go or something, and the thing would sit there and go rrr rrr rrr and the table would shake, carry on for a minute or two, and then finally it'd decide it was through and it'd quit and come to rest and you'd look up there and read your answer. So that was weird. And then of course later on when we got computers, real computers and all that, but that's some of the kind of equipment we had to work with.

A lot's been said about the computers on Apollo, and that's true. I mean we just didn't have the technology. So they were very rudimentary computers that we had in the Command Module. But that's all we had. Those were the days when you wanted to do engineering calculations, you'd use Fortran and you'd use punch cards, and you'd punch it all up on punch cards and then you'd take it over to the computer lab and put it in, and then leave it there, and they'd run it for you overnight, next morning you'd go get your answers. The same thing at the universities. I mean that's all we had.

Printing was the same idea. It was the technology at the time were ammonia blueprints. Ammonia prints. Ozalid prints. Stinky things, smelly things. Get on your fingers. Mimeograph machines, all that kind of stuff. Of course then Xerox came along and invented you know the dry process. So yes, things were a lot different back there, what we had to work with. Which later on I can talk a little bit about when we started working with the Russians, when they became our friends instead of our kind of competition, our adversaries. Our early days is how we had to deal with all that. But yes our technology was different back there -- the tools that the engineers had to work with as well as for analyzing and calculating and designing and so forth as well as testing and verifying.

So tools make a big difference in what we can do today -- and we get some of the young people that can go bzz bzz bzz bzz like that and they've got the job done just in a blink, and it'd take us days and days and days to do that back then. When I sit back and think about, I haven't thought about it for a long time, but how in the world did we do what we did with what we had to work with and the time we had available?

We didn't have much of a budget problem. The higher management, [James E.] Webb and [Robert C.] Seamans [Jr.] all those guys, Shea and all of them, they took care of the battles with the Congress over the monies. But us in the working trenches, we didn't have any money problems. If we needed something we got it. So our biggest problem was just the technical challenge of how the devil are we going to do this job and how are we going to do it in this timeframe. But we didn't have money problems back then.

We didn't have much in the way of -- what would I call it -- institutional paperwork. We had a lot of technical paperwork on purpose, to control things. But we didn't have much in the way of institutional paperwork. We had to do a lot of shortcutting. We were kind of lean and mean and going like crazy. We didn't have a lot of overhead. We didn't have a lot of burden, if you like, burdensome things. We used to talk like we were the cream of the crop of industry joined the cream of the crop of the Space Task Group to get a high-tech job done in a hurry that nobody'd ever done before.

No, Mr. John Q. Public, we were not like the usual government agency where they sit around and throw paper spit wads, you know, and not do anything all day long and all that like the Department of Agriculture or somebody else. I don't mean to demean anybody, but that was the general view. I remember we got faced with that quite often in the early days. What, another

one of those government agencies? No, we're different. We are different. And we were. We were different. So no, we didn't have much institutional paperwork.

Now as the years progressed we noticed that more and more of that was coming. And I suppose rightly so. It is a government agency after all. But we didn't have much at the start. If we needed to do something, we didn't have to get a lot of approvals either. This is why I like "Burt" [Elbert Leander] Rutan right now. Because he's kind of where we were back then. He had a lot of flexibility to be creative and just go do something.

If you had an idea you could go out and try it and do it, you didn't have to get all these approvals, you didn't have to go through lots of hoops and so forth, you just went out and tried it. You didn't have to go to all kinds of review boards, you just went and tried it, and if it didn't work, okay, we'll try something else. So we had a lot of that going on. If something didn't work right on Mercury or Gemini and Apollo, why, you can get your chewing gum and -- it's RTV [Room Temperature Vulcanization], but we called it chewing gum -- and you go you know put it on there, hold it, do something. It's like the canopy that we put on Skylab. You know, that was kind of a jury-rigged thing that we did. I don't know if we could do that today, would be allowed to do that today. [And, by the way, we could not have done a lot of the things that we did without the help of Jack A. Kinzler of the Technical Services Division and his shop, machinery, and people.]

Well I'm kind of veering here, sometimes I kind of think that the safety -- oh I'm a firm believer in it and you see later on that I kind of got involved in that aspect when I broadened out into systems engineering -- is very important but you can go overboard, like you can anything. I think sometimes we've gone way overboard and way, way, too protective. The safest you can be is don't fly at all. So you've got to take some risk if you're going to do these things. And yes it's

sad that we lost the crew on Apollo 1 and *Challenger* and *Columbia*. But that's just the way it goes. The guys that fly it, they understand that, and they know that. We do the best as designers and creators of the hardware to mitigate all the bad things that could happen, but you can't insure it 100%, there's just no way. Can't do it. Minimize it, yes. Anyway I don't know how I got off on that.

ROSS-NAZZAL: Why do you think the culture back in the '60s was so flexible?

WREN: Probably one thing was because we didn't have very many of us. Even with adding on the industry guys like me and Canadair and some of the others brought in, there still wasn't a whole lot of us. We didn't have a lot of layers of groups and -- I don't know, institutions and departments and stuff to have to go through. We just went and did it, kind of like a big old series of short circuits. For example, in Apollo we had the standard management hierarchy, both in line discipline management as well as project management, classic. And they were all set up, and of course they varied and changed because it was hectic and everybody was in a hurry.

But we also had an underground -- I wouldn't say management, an underground connection if you like of technical people. They weren't necessarily always at the same level. There was no telling where they would be. They might be at a higher management level. They might be more at a grunt level.

But you knew, you got to know real quick, where the sharp people and what they could contribute and help out with. You kind of drew in this not published, unpublished group of folks to work on things, and you'd grab them and get them together and do things. I know many many times when we were trying to solve some dynamic problems when I was still in VATF I grabbed

people like Dick [Richard A.] Colonna and Owen [G.] Morris, all different levels. Dan Newbrough, and of course the guys from the contractors at all different levels. Heldenfels out at Downey. Just to get the job done technically.

You're trying to work a technical problem and find a solution and an answer and a way to go. You didn't pay much attention to departments and levels and authorizations and all that sort of thing. So we had a lot of that going on with our small bunches. So that gave rise to a lot of flexibility. Because we knew that we can hey just call up the phone. Of course we didn't have emails back then. We actually talked to people, you know, either face to face or telephone. We didn't have cell phones so you had to pick up hard line. But we did a lot of that. We got people together all hours of the day and night in to try -- it was a continual series of problems. We were problem-solvers. Problem after problem after problem. We solved one problem, then we'd go on to the next one. Because we were doing things nobody had done before, so we didn't have anything to go by. We didn't have any criteria. So we had to kind of find our own way if you like.

Now physics is physics, and engineering is engineering and math is math. So that's okay until we find out more about black holes and wormholes and things. But as we understand it, those principles still are true. But how do you utilize all that in specific applications nobody had done before? So we had a lot of inventing of the wheel so to speak to create this hardware to perform the function that it was asked to create, to perform, to do. I mean it's like the flag, you know, on the lunar surface. We got hit about that because we didn't go there. The Flat Earth Society said we went to New Mexico somewhere, Arizona. To prove it they said well you know there's no air on the Moon and yet the flag's standing up straight, like it's blowing in the wind.

Well of course it is. We knew that. We put a wire in it so it would stand up. (Laughter) I mean you know.

ROSS-NAZZAL: You mentioned that you dealt with a lot of challenges during the Apollo program. Could you walk us through some of the ones that stand out to you that you worked so diligently on?

WREN: Well, the one I referred to earlier was trying to figure out some way to simulate that very unusual acoustic environment on our Apollo spacecraft, and we did that. We solved it. That was a challenge and fortunately we were successful. So that was a challenge.

For me personally -- and this'll be -- I guess I haven't talked about that yet, but after I left VATF I went from -- how would I say it? Very narrow and very deep technically and research work and so -- I was very narrow. I was in structural areas and structural dynamics and had to learn acoustics and so forth. Little bit in some of the other technical disciplines but I was pretty narrow, pretty deep, and that's what I did my research and my graduate studies on. Then I did a whole paradigm shift when I got called upon -- and this I guess is another era.

Getting ahead of myself, but I got called upon to go do something else, which was 2TV-1. Now all of a sudden I was pulled out of that environment. I gave up my group, my section. I was a section head. They don't have sections anymore. Back then we had sections and branches and divisions. Pulled out of that and put into what I would call a broad technical environment where I had to become a project person that dealt with more of a systems approach and system engineering, where I had to become capable of orchestrating a broad-based project with lots of disciplines and have just enough knowledge of all the different disciplines to know what smart

people I needed and how to converse with them, but then let them go do all the work, because they were smart and they knew how to do it. So that was a whole different thing for me. It's to become kind of like a systems manager if you like, system engineering or project management. Well how did I do all that?

Well, that was a challenge then. So that meant, ooh, well, I got to go to a different kind of school. Now I got to go to management school. So they sent me to a lot of them and some I signed up for. They're in some of this backup material, that's all the different management schools I went to. Of course I'd already been to some supervision schools because I was a section head. But I had to go to how to manage people schools and seminars and this, that and another thing. Some of them were here in Houston and some were across the country here and there. I can remember some of them were kind of funny.

One of them I went wasn't necessarily that funny but I'll never forget it. I ended up in one seminar down at the Jack Tar Hotel in Galveston. It was a Kepner-Trego course and the guys that I would go on to work with later on were there with me at the time. And that was the first time I got to know them. People like Bob [Robert L.] Blount, Chris [C.] Chritzos, Clay [E.] McCullough, [Donald D. Arabian] I can't remember all the folks I worked with in that weeklong seminar down there. It was very good training, excellent training to teach me how to be a systems engineer and a project manager.

Then another one I went to out in Ojai Valley, California; it was an encounter group, of all things. We went up the valley to this country club, golf club thing up there and came in and it was supposed to teach you how you interrelate with people. Went in and sat down and sat in a circle. The chairs were all in a circle and sat down in a circle and we sat there and sat there. It was about ten or fifteen of us. We waited and waited and the time went by and time went by. Of

course when I was teaching, why, you got what was it? Ten- or fifteen-minute walk. If you weren't there, why, your students could leave.

So we're sitting there and we're waiting. A half-hour went by. Where's the leader, where's the guy? And so then we started talking about this absent leader. What about this guy? He's not here. Then we started noticing there was one guy sitting there, and he wasn't saying much of anything. (Laughter) And everybody, this time, why, slowly everybody was chattering, and this one guy never did say -- and it turned out that that was our leader and he'd sitting there all that time. Dr. Henry Work.

ROSS-NAZZAL: Was that some sort of test?

WREN: Yes, he's a psychiatrist, emeritus something or other at the University of California – Berkeley [California] or somewhere. I don't know. But anyway as a technical engineer having to go through that encounter group, it was a strange thing for me. So that was new and different.

ROSS-NAZZAL: What were some of the challenges that you faced moving from that very technical field to a much more broad management position?

WREN: Well, I had to think in broader terms, be less prone to core-drill specific subjects unless [I] really needed to. Because I wouldn't understand them anyway. I had to become conversant though with avionics, with propulsion, with cryogenics, with batteries, all these other disciplines: communication and tracking, guidance and nav [navigation], on and on. Thermal, thermodynamics, passive thermal, active thermal control, all the different systems and

approaches needed for those kinds of disciplines. I had to become familiar with all of that stuff. And I wasn't so much. So that was a challenge. I had to hit the books and learn that stuff real quick just sufficiently so I could work with it, work with the experts. I had to do that before 2TV-1 in a big rush because when we got to 2TV-1 that was a fully systemed vehicle with crew. I had to be conversant enough with the total system to be able to lead it. Anyway that's another chapter. But yes that was a challenge for me and I think I managed to do it okay, but it was new at the time.

ROSS-NAZZAL: You moved out of the VATF and you moved into the SESL? Is that correct?

WREN: Yes, what happened was that the Block II Command/Service Module needed to be thermalvacuum tested. Block I was created for Earth orbit and it didn't have some of the features that we needed for the lunar mission, because we were in a rush and trying to do some things in parallel. So we did a lot of the structure testing for example, or quite a bit of it, on a Block I vehicle, because it didn't matter. It wouldn't know the difference. But when it came time for the lunar mission we needed a Block II vehicle with a transfer tunnel in the forward section and so forth. So we needed to test that to see if it would withstand the thermalvacuum environment that the bird would see going to the Moon, around the Moon and back again.

So we had a chamber here in Houston in SESL, Space Environment Simulation Laboratory. Chamber A. There was Chamber B, a smaller one. Chamber A is huge. I don't remember the size of it. I think 32-foot or something. It was big. Anyway suffice it to say it was big enough to contain a whole Command/Service Module inside. So it was decided that that

needed to be tested, and that was the place to do it. So they needed somebody to put all that together and do it. And so they called on me.

There's announcements and stuff that went out and so forth. So what they did is they transferred me -- and I have to couch it in the context of what was going on at the time. Everything's helter-skelter, hurry, hurry, hurry. A lot of times things happened, and paperwork if any at all would catch up maybe sometime later. So what they really wanted me to do was to work with the program office but still be in the Engineering Directorate. So the way they solved it is I think they assigned me to Jim [James C.] McLane's SESL, to his organization. I kind of still worked with Jim in SESL and worked with Joe Kotanchik and Bob [Robert E.] Vale in the Structures Division and George [E.] Griffith and some of the others. I don't remember all the names. But what I was really doing is I was assigned to and working with the program office. For 2TV-1 I was assigned to work with Rolf [W.] Lanzkron, who was the manager for the Command/Service Module in the ASPO, in the Apollo Spacecraft Program Office. So that was my task, and what I was charged to do was to mobilize the manpower and resources to get that test done. [I had a standup progress review with Rolf almost every morning, early, at 6:30 or 7:00 am, I believe. I also had periodic reviews with George M. Low, Robert R. Gilruth, Christopher C. Kraft, Faget, and others. We had plenty of support and keen interest from upper management.]

That test became a direct constraint on Apollo 8. We could not fly Apollo 8 out and around the Moon and back with [Frank] Borman, [James A.] Lovell and [William A.] Anders. We couldn't fly that mission at Christmas. Turned out flew at Christmas and they read Genesis, all that. We couldn't do that if we didn't finish satisfactorily this thermovacuum test using 2TV-1. So we had to do it in a big rush. We had to do it with a lot of folks. I was asked to mobilize

that effort and do it. Thank goodness I had just gone to all those management schools, so I kind of knew what it took to do it.

Now the way we approached Apollo was a subsystem manager approach. What that meant was that it was set up so that we had a lot of civil service guys who were in charge of specific subsystems. For direct control to speed up the whole Apollo process, [NASA] Headquarters [Washington, DC] set that up, [George E.] Mueller and them. So that meant I had -- what did I have? Well first of all had the facility. I had Jim McLane's chamber facility and all the people that it took to operate the facility, you know, to close the door, to pump down the vacuum, for the instrumentation they had set up. All the things it took to operate a vacuum chamber of huge size. That was a whole group of people. Okay, who else did I have? Now I had the spacecraft. So I had to have the subsystem managers, the NASA civil service, to do all their systems.

I had to have their counterparts from the contractor, in this case North American at Downey. So I had a huge engineering bunch that was a counterpart to our subsystem managers from Downey, who when it came to actual test time quite a few of them actually showed up on site, as well as doing things from Downey. Then I also had from Downey all of the technicians, North American technicians, under John Stungis, that knew how to handle the actual spacecraft and the equipment. It was fully systemed, so you had to have the technicians from Downey who knew how to handle, turn on and operate and handle, the spacecraft systems. I had all those folks. That was John Stungis's bunch. And of course the engineering part from Downey was Ben Boykin and David Llorente and those guys. They provided the engineering or project back up.

We had another thing set up in the program office. We had sometimes a single person and sometimes two, three, four people who were agents of our civil service project office who were in charge of keeping up with specific spacecraft. Spacecraft managers. And on 2TV-1 the lead guy as I recall was Don [L.] Teegarden. Very fine person, very sharp. I can't remember the name of what we called those people. But maybe you know. But anyway so he had counterparts, that's my point. He had counterparts out at Downey in engineering at Downey. So all those people were involved, either remotely or came.

So all told I probably had -- gosh, I don't know, couple hundred folks involved in that thing. It lasted about oh, a little less than a year. I think it was 1968. I think we started in the first part of '68 and we finished towards the end of '68 as I recall. I think that's right. I think we did the actual testing during the spring of '68. I think that's right. Around March or so. And then of course we had to analyze all the results and write and publish the test reports and findings and so forth.

But when we actually ran the test it was about a week long, I think it was about seven days. And oh, the other thing I had then left out -- how could you leave out? Is ops and the crew. So we had ops involved because ops had to be able to -- they were learning at the same time, they're learning how to operate the vehicle, because they're going to have to operate it when it actually flies. So I had all kinds of ops folks participating.

Then I also had the crew. I had Joe [Joseph P.] Kerwin, Dr. Kerwin, which is another small world bit. I had worked with his brother up at MIT when I was doing that vibration research stuff. Joe always referred to his brother -- his name was Richard -- as the smart one. I says come on Joe, what do you mean, the smart one. (Laughter) But anyway so Joe's a great

guy, love him. Joe was the commander, CDR and Vance [D.] Brand was the Command Module pilot, CMP.

Joe [H.] Engle was the Lunar Module pilot, LMP. Joe had interesting background too. He's a character. I don't know if you know Joe but he's a lot of fun. Joe was an Eagle Scout among other things. Have you ever heard of the Blackbird SR-70? He flew the Blackbird, which is monumental. Of course it came out of the dark world, but I mean that thing goes like crazy and goes up real high. They had one up at Marshall sitting there on display for a long time. I don't know if it's still there or not. Of course they got one up at the National Air and Space Museum at Smithsonian in Washington [DC]. But anyway Joe came from that area. So I mean he was a hot jock, you know. But all three of them were fine, fine people. So I was responsible for their involvement in the effort. The crews always had a helper, kind of like a horse holder.

These three had a helper by the name of Joe [Joseph A.] Gagliano. And Joe Gag was a riot. He was also a pilot and he would be the intermediary and he would be the kind of coordinator for the crew and their time and where they -- were they going to be at Downey or they're going to be here, there, you know, and all that sort of thing. And he'd come in sometimes to some of our meetings, and he'd say oh, and his neck would be all -- oh, holding his neck. I said what happened to you today, Joe. He said I was pulling too many Gs this morning. Got a crick in his neck. Joe Gagliano, he was a lot of fun. Joe Gagliano, by the way, that's another -- you want another funny?

When I first got assigned to this job the first thing I was tasked to do was to go to Downey and meet all the folks and so forth. So flew out there and the night before the meeting got in and we all had agreed we were going to gather at the Tahitian Village and have a drink and so forth. We were there at the bar and having one of those things with an umbrella on top and all

that. And all of a sudden this voice comes across the way. Somebody's approaching. He's yelling real loud. He says, "Where is that whiz kid I've heard so much about?" (Laughter) Turned it was Joe Gagliano. He was looking for me. With a little skinny tie and a flattop and 20 some years old or 31 or whatever I was at the time. I don't remember. But I just thought that was kind of funny. He didn't mince any words. He was fun. Of course I wasn't any whiz kid. But anyway that was the group of people that we had together. It was fun. It was fun. It was hard work. It was stressful. But it was fun. There was a lot of folks involved.

ROSS-NAZZAL: Yes, it sounds like it. … You mentioned you really started working on this about a year before you had the test. What sort of things did you have to work out before you could have this seven-day test?

WREN: Oh, okay. Well, first of all we had to -- in conjunction with the smart people -- and when I say the smart people I'm talking about the technical experts for aerodynamics, thermodynamics, passive thermal control, so on and so forth. The people that knew about the capability of the surfaces of the vehicle to absorb the solar energy or reject solar energy. We called it alpha over E, emissions, absorption-emission ratios and all those kinds of things. We had to come up with the test conditions that would be appropriate for the solar environment. And of course the vacuum was pretty straightforward. We were going to pump it down as far down the vacuum as the chamber would go. So that was pretty straightforward. But the main thing was the thermal conditions.

The other thing had been developed as part of the design of the vehicle for thermal control, passive thermal control, was what we called a barbecue mode. The barbecue mode was

a roll maneuver where we rolled the CSM like on a barbecue spit around the central x-axis. We just rolled it, continuously rolled it. And why did we do that? We did that so that we would have even temperature control on all sides of the vehicle, external sides of the vehicle, so it wouldn't get real hot on one side and colder than the devil on the other side, because it's the vacuum of space. So that's what happens in the vacuum. You're either real hot or you're real cold. Because there's no air there so you don't get any convection for your thermal energy.

We put the whole CSM on a turntable in the middle of the chamber. And the way the chamber was designed and set up, it had a bank of solar lamps to simulate the Sun, solar energy. So we put the CSM on this turntable and then we'd slowly rotate it at the same rate that we were planning to do it when we flew, so we'd get the barbecue mode simulated. You had to go through and calculate you know all that and what were the parameters involved in all that to do that job.

I don't remember all the conditions. The smart guys had all that. Any time where you're blocked from the Sun or from some of the Earth's light albedo, then the thermal conditions would change. So we had programmed in to run the bank of lights either high speed, full speed or partial speed in addition to the barbecuing. All this was orchestrated very carefully. Once it was all orchestrated and so forth, then that became the test plan of what we wanted to do to do the proper simulation to cover all the parameters that the bird would encounter when it actually did the flight around the Moon and back, circumlunar. So once that was established then you had to put that down.

Now we go back to our very tight process control. You had to put all that down in writing. So all the team members were all marching together. Everybody knew what to do. It was all playing together like an orchestra. It was very carefully controlled, the whole thing.

What time do such-and-such lamps come on? When do they go off? You know, etc., etc. So all that had to be then put on what we called again TPSs or test preparation sheets. It essentially became the menu or guideline, the bible, if you'd like, for the test. Of course all that had its review cycles and we went through flight -- similar to flight readiness review. Test readiness reviews and so forth. All the technical disciplines had their oar in that, creation of that. And then the okay of that, the final versions of what we were going to do and so forth. So that entailed quite a bit of time before we ever got started on the test obviously.

The other thing was to set up all of the systems for measuring what results we would get. We were taking a lot of thermal and what would I call it? Structural data. You know, how hot did things get, and so forth. We had thermocouples all over the place. And of course that was instrumentation, so it had to go to instrumentation processing equipment and so forth. Then recorders and so forth. You know, tape recorders, oscillographs, whatever we had at the time.

Then on top of that then we also had all of the spacecraft operating systems since it was going to be operating, just like it would in flight. So all its subsystems and so forth were operating. So what had been created was something called Apollo Checkout Equipment, ACE, and then we also had a smaller version called PACE, Portable. But what this stuff was, it was created -- I think it was by GE [General Electric] if I remember right, but anyway it was a whole bunch of equipment that would operate the spacecraft systems even though you were on the ground just like you would be operating it either by the crew in flight or by mission control in flight. So it was a simulation of the operation, conducting the operations of the onboard systems.

So we had all that stuff that we had to bring in from Downey and put in place. That's another reason why we needed so many technicians from Downey, to operate all that stuff, set it up and operate it. That made the bird come alive, if you like, powered up, and now it's humming

and going. Its cooling systems are operating and its life support systems are operating. The oxygen systems are operating because we got a crew in there, and they got to breathe. It's got all to work right. And of course the coms [communications] systems and so forth. So all that had to be set up and put in place, and all the planning ahead of time to be sure that was done, and where were you going to put all that stuff, and who was going to operate it, and it all dovetailed into a massive plan and became these TPS sheets that everybody ascribed to.

We did the same thing in mission control. We fly a mission at mission control, it's all on paper. Everything that's done by the ground controllers and the flight director is done with paperwork or on the computers, but its process set in place. And it's a lot of time and effort's going into that development ahead of time to be sure it's right. Now every once in a while you'll run into an anomaly and then you go off to a side room and you say work this problem. But those are anomalies, the way you work with anomalies. So we had to do all that for this test too. Same thing. We had like you have a flight director, we had a test director, so on and so forth, so set up the same way.

Then for the crew, the same idea, we had all the things that went with the crew and their support equipment and so forth, put on the suits and carry their support equipment with them up until they enter, you know, and get inside the vehicle and all that to keep them cool and breathing and all that. And so we had that to deal with. Well, just everything it took to do it. Did I tell you about the water guy?

ROSS-NAZZAL: No.

WREN: Oh. That's another one of the nice things I liked about my career. When I got into doing this kind of project work I was a firm -- and still am -- a firm believer in giving credit to all the participants, due credit. Because so often they're never mentioned. I always went out of my way to be sure that they got awards, commendations, letters. I would send out letters of appreciation to the recipient and with copies to their management. So they would all know. I just believed in that. I thought it was a nice and right thing to do. My water guy, Sauer, Dick [Richard L.] Sauer, and he was a toxicologist in charge of being sure that the water didn't have any bad things in it so the crew would get sick in Apollo. So he was if you like the subsystem manager for water. Okay, and he was on our team, on my team, along with the rest of a lot of other ECLSS, what we called ECLSS folks, Environmental Control and Life Support Systems. Well years later -- and of course when I sent out the usual things when we finished 2TV-1 and years later I bumped into Dick in another venue doing something else; he came up to me and he says, "I want to thank you." He had risen up through the ranks through the years. He said, "I want to thank you, I've never had an opportunity to."

I said, "Thank me for what?"

He said, "Well because you're the reason why I managed to rise up through the management ranks in my career."

I said, "What?"

He says, "Yes, because that letter that you sent to my management about my performance on 2TV-1 opened the doors and paved the way for me to go places that I desired to go."

I said, "Wow! All right." So I take satisfaction that I helped somebody and I made a difference perhaps. So anyway I don't know why I happened to think of that.

ROSS-NAZZAL: That's important.

WREN: But that was one of the guys that was involved of the couple hundred people or so.

ROSS-NAZZAL: When you ran the test were you running it 24 hours a day?

WREN: Yes. Round the clock 24/7 for seven days. I think it was seven days.

ROSS-NAZZAL: And were you keeping those kind of crazy hours since you were in charge?

WREN: Oh yes, oh yes. Yes, you know I had other people doing things and a test director and all that. Oh yes I was there, practically lived there, right, right, yes.

ROSS-NAZZAL: Did everything go well or were there any anomalies that you recall?

WREN: The bottom line out of that as I recall was that we had no problems with the Apollo Command/Service Module hardware or equipment. It all performed as advertised, thank goodness, because we didn't have much time, and we didn't have any room for error, and remember it's a constraint on Apollo 8. So we had to get an answer and it had to be right, and if we found something major wrong, (whistle) that hit the whole program schedule. The crew always when they participated in things like this wrote up crew reports.

As I recall Joe and them came up with oh some small items like I think they said there was some water dripping off some of the condensate lines and so they had a little drip, drip, drip

and maybe a little wetness. No big deal. They said as far as they were concerned it was no big deal, even though they had 10- or 12-page report. But they were selling it by the pound so they -- no, they had -- I think they had some trouble with some of the food bags. They had some trouble with some of the comm. equipment. I don't remember the details of some of it. But there were minor things. So the bottom line is that it was a success. Everything turned out fine, thank goodness. It was cleared to go and the constraint for Apollo 8 was lifted. And we were good to go to the Moon without a LM and get there and show the Russians that we could do this. Look, we're going around the Moon.

ROSS-NAZZAL: Well, I think this'd be a good place for us to stop and pick up actually with the testing of LM-2 next time. What do you think about that?

WREN: Okay, okay. That'd be great.

ROSS-NAZZAL: All right. Well thank you very much.

WREN: All right. Well thank you. Appreciate it.

[End of interview]