NASA STS RECORDATION ORAL HISTORY PROJECT
EDITED ORAL HISTORY TRANSCRIPT

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INTERVIEWED BY JENNIFER ROSS-NAZZAL
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ROSS-NAZZAL: Today is July 12, 2011. This interview is being conducted with Jerry Sheehan at the Kennedy Space Center [KSC] in Florida as part of the NASA STS Recordation Oral History Project. The interviewer is Jennifer Ross-Nazzal, assisted by Rebecca Wright. Thanks again for taking time out of your busy schedule today to meet with us.

SHEEHAN: My pleasure. Today is one of those very rare not busy schedules.

ROSS-NAZZAL: The launch went off.

SHEEHAN: The launch went off fine. The mission is going extremely well. In fact the guys at Houston [Texas, Johnson Space Center] even have time to do some practical jokes. I just saw a picture they sent in. Gene [Eugene F.] Kranz, on I think it was Apollo 13, and the original mission crew. I never can remember the other guy's name that was on the off shift with Kranz on Apollo 13.

ROSS-NAZZAL: Glynn [S.] Lunney?

SHEEHAN: Yes, it might have been Glynn. You're the history guys. You know this kind of stuff. There was a whole black-and-white picture with everybody with black pants and white shirts and skinny black ties and the guys in the DAT [Damage Assessment] Team, who since there's hardly any damage or anything of interest on the Orbiter TPS [Thermal Protection System] to work, all dressed up in white shirts and skinny black ties and vests with Apollo mission patches on them. You can tell it's a good day in a mission when everybody has time to act the fool, play a little game, play jokes on one another. Gene Kranz came in so he's in the new picture as well as the old ones. That's a good thing.

ROSS-NAZZAL: That's a nice tie. Well, tell us if you would how you became involved with the Orbiter Project in Rockwell.

SHEEHAN: How far back should I start? October 1950? Is that too far back? That's when my parents moved here from New York. Although the space program was three months old [by then] out at Cape Canaveral Air Force Station [Florida]—I'm not even sure it was Cape Canaveral Air Force Station then. But in any case Dad had a sporting goods store in downtown Cocoa [Florida], so I grew up in the area. Growing up with rockets (somebody's already used that title on a book or a film), I strangely enough wasn't enthralled in the business and wasn't really going to go into the space business, although I always had a leaning towards math and science in school.

I got interested, as most teenage boys [did], in the '50s and '60s in cars and girls, not necessarily in that order always. I was actually thinking about going to work for General Motors. Well, they were a lot more interested in other people than they were in me. About the same time, I started thinking about maybe I want to have an actual job that pays something. It's always good for a life goal, I think.

[It] would have been my junior year summer in college; I went to the University of Florida [Gainesville], was majoring in aerospace engineering, and I made the rounds of all the contractors on Cocoa Beach. North American Aviation, who had the second stage of the Saturn V lunar rocket, and of course the Apollo Spacecraft, said, "Yes, I think we can use somebody that's going to be an engineer pretty soon."

I got a summer job. Actually, the year before that I worked for the [U.S. Army] Corps of Engineers. I was out of my league in construction. But what do you need from a summer intern, right? Stand out in the sun and count chunks of steel on the ground is good enough. So I had a job with North American the summer of '66. I came back after I graduated in April of '67. I started May 1st of 1967 and have been working for the same company under five different names since then.

ROSS-NAZZAL: That's unusual these days.

SHEEHAN: Very unusual. In fact I don't know of anybody else in the organization that has that kind of fortunate longevity. Anyhow, I worked just as what we call an intern today. It was a summer job. [I] got exposure to a lot of different engineering groups. I had a leaning towards big picture kind of stuff. I wasn't all that interested even then in specific little pieces of hardware, parts of systems, or parts of testing. I worked with a fellow in [what] today we would call it an integration function. He was working on countdown procedures for the Saturn V. So I worked that summer. Went back to school. I graduated, came back here, got a job.

Curiously enough, North American made me the highest offer by about, I don't know, $100 a month. It was all of $720 a month in 1967. I guess most people make that in a week and are still on welfare today. I got a job. I started working again in that same integration group. That lasted for about, oh, I don't know, couple months. Then I went into propulsion and spent essentially all the rest of the time in the Apollo Program working propulsion either as a system engineer or as a—we called them system specialists back in the day.

Along about late '72 or so, I got asked by one of the fellows who was in the test conductor organization—I guess it's actually properly called the Test Operations, I forget what formal name it was too—to do some white papers on Shuttle preparations for checkout and launch kind of things down here. At the time the Orbiter really was supposed to be like an airplane. It had jet engines on it for atmospheric flight. So I treated it like it would be an aircraft test program, doing runs into the SLF [Shuttle Landing Facility], landing approaches, navigation checks with the ground equipment, and that sort of thing. Of course that all went out the window a few years later when we converted to an Orbiter and Carrier Aircraft mode of transportation across country.

Anyhow, that was probably just about the time that Rockwell won the contract to build the first two Orbiters. They also got a Systems Integration contract at the same time. [Down at KSC], we had just finished up with Apollo 17, the last lunar mission.

I got a call from a fellow who had previously been a Test Operations guy for Spacecraft for Apollo and had gone back to California to work on the proposal for Shuttle. He called me and said, "Hey, how about coming out and joining the integration group as a systems integration guy working External Tank and other things." I said that sounded good at the time. I had a wife that was about six months pregnant and a dog. So we packed up and moved to California.

I started working on Shuttle in January of '73; I think the last week in January is when we got there. Let's see. We still had [Saturn V] flight vehicles at the Cape. Part of my release to get out to California in January was I had to come back in April for the launch of the Skylab Booster. So that was actually the last [Saturn V] launch crew I was on, because as far as we were concerned the first and second stages were just like a lunar flight. You just went to Earth orbit and stayed there with the lab.

I went back to California. The guys still had the smaller Saturn vehicles that launched off the milk stool on the mobile launcher. No, I missed the [correct name for that] program. It was the same thing but it was called a Launch Umbilical Tower [LUT] at the time. So we had three more launches, the Spacecraft guys did, off the LUT with the milk stool on it. I never understood why they called it a milk stool, because it didn't have three legs, it had four legs. It should have been a barstool. I guess that was politically incorrect even in the '60s. In any case, the guys that stayed here had three more launches for the Skylab missions and then another launch for the Apollo-Soyuz Test Project. None of which I had anything to do with, because I had a full-time job in California by then.

I['ve] got to back up a little bit. When the Shuttle vehicle was originally concepted, there was a lot of things that were at the time undefined, like aeroheating environments and natural environments that it would operate in. So the folks at Marshall [Space Flight Center, Huntsville, Alabama], who were managing the External Tank proposal and evaluating the industry responses, did not have a requirement to, like we do today, preclude icing on the Tank. Those of us in the business who were around in the Apollo Program remember pictures of the Saturn V taking off from the pad, and all the sheets of ice raining down the sides of the vehicle. There wasn't a requirement to preclude that from happening on Shuttle. In retrospect how the Program could have missed that as a requirement is beyond me. I never really did investigate why that was the case. I had the job to go figure out what we could go do about it.

That obviously was not a new problem. It had been studied [before]. I found out that there was a paper in the Downey [California] technical library [by] a fellow that, at the time I was involved, was working for NASA at Houston, and he turned me on to the paper. At the time it was written about cryogenically fueled or cryogenic propellant launch vehicles. Actually I think most of his work was done on Atlas. It was probably in the early to mid ’60s that he had done this paper. His interest was in terms of flight performance, because obviously if you don’t shake all that ice loose on the ground before you take off you’re lifting more weight than what you had anticipated. So his main focus was on performance. My main focus at the time was on the damage that ice falling off the Tank could do to the Orbiter. By that time the Orbiter’s Thermal Protection System had been settled on as being silica tile. My friends at Marshall always called it the glass slipper.

The Tank proposal from the Martin Marietta Company, who subsequently became part of the Lockheed Martin conglomerate who today build the Tank, did not have a requirement in their request for proposal to preclude icing or anything else. They also didn’t have an ascent aeroheating environment because the integration contract that Rockwell had hadn’t yet defined that.

So they mention in their proposal that gee, we have enough insulation on the Tank, foam insulation on the Tank, just like it is today, the proposal baseline Tank. But it’s only a half an inch on the hydrogen tank and none on the LOX [Liquid Oxygen] tank, which obviously would create icing problems and performance problems. So they recognized [that] in their proposal back to Marshall. They said, “Gee, we need to do something to preclude icing, and we probably need something. Once we recognize or are provided what the aeroheating environments are, we probably need insulation on the top of the LOX tank.”

So I had a lot of work to do with the natural environment people, defining what the design natural environments were going to be at KSC. At the time we were still going to launch out of the Western Test Range [Vandenberg Air Force Base, California], where it's very nice and wet and cold and foggy, and at KSC where it's just wet most of the time.

Those environments were conducive to ice forming on the Tank either from condensing of moisture in the air, high humidity, or precipitation, rain, or, on the West Coast, fog. So we knew we had—at least we at Rockwell knew we had a problem that we needed to get the Program to recognize and define a requirement that the Tank preclude icing.

So we investigated. Actually it wasn't just the [External] Tank. That would have been the easiest thing to do. Just to say, "You guys on the Tank insulate everything so it doesn't form [ice]. It's never less than 32 degrees Fahrenheit anyplace on the Tank under any environment that you'll ever try and launch it." That would have been the real easy thing to do.

Obviously the folks at Marshall and the folks at Martin didn't want to take the weight penalty that would be involved in doing something like that. So they were looking. As every element of the Shuttle had a weight bogey, a weight allocation from the Program, they had one which at the time didn't include any insulation to preclude ice. They weren't interested in volunteering a couple thousand pounds of insulation to help those other [Orbiter] guys. They wanted to be directed that that is a Program requirement. Then they would be able to increase their weight bogey and not have to take the weight for [anti-icing] insulation out of the weight that they were allocated for structure and other Tank systems.

So it took about—oh, it was at least six months or maybe a year before we had briefed the Program with enough data that they actually recognized that there was a necessity to recognize an anti-icing requirement, I guess is the best way to say it. In the meantime we had looked at all manner of ground-based and other systems that would help in the on-pad environment at least.

The French, at about that time, had come up with a jet-engine-exhaust-based system that precluded fog precipitation, high relative humidity in the natural environment if you will, at one of the airports. It might have been Orly [Paris airport], I can't remember anymore. They had buried or installed jet engines in—catacombs may be a little too dramatic. They had put jet engines along the runway, below ground but along the runway, and had ducted the exhaust so it blew out over the runway. And that was enough to raise the temperature just a few degrees and preclude fog on the runway.

At about the same time one of the NASA Centers that was big in aircraft propulsion at the time—and I can't remember, I think it was Glenn [Research Center, formerly Lewis Research Center, Cleveland, Ohio] was doing hydrogen fuel jet engines. I put two and two together and said, "Gee, if we want to warm the environment around the pad," and we had this big umbilical tower next to the vehicle, "why don't we just put jet engines up the side of the tower? Since we don't want hydrocarbons depositing on the Orbiter TPS and on the Tank and everything else we could just use hydrogen." We got hydrogen boiloff. It was a way out crazy idea, but it was an integration of a technology that existed, a utilization that somebody else had done, a use of a commodity that we had in abundance as part of the boiloff, and was trying to preclude an impact on the flight vehicles. The Tank wouldn't need as much insulation if you could warm the environment.

As it turned out everybody said, "Yes, right. Okay next page." But the last laugh I had was that when we were getting really close to actually launching a vehicle off of SLC [Space Launch Complex]-6 in Vandenberg there was a lot of concern with hydrogen from the SSMEs

[Space Shuttle Main Engines] as part of their normal prelaunch operation. They bled hydrogen off. [During] the start sequence of course you start out with a fuel-rich mixture ratio.

[The hydrogen] got down in the exhaust ducts because of the shape of the pad and the geometry and geography of the area. The pad basically sat flush on the ground, and they had tunnels underneath to duct the exhaust away. There was a lot of concern with accumulating hydrogen in those tunnels and then it detonating and creating pressure waves and damaging the aft of the Orbiter, similar to what we found out here at Kennedy for a different reason. So they wound up putting turbine engines down exhausting in the flame ducts to move the air through there, because the exhaust acted as eduction devices that pulled the air down through the top of the pad and out through the duct, and of course with the controlled fire from the jet engines, you would get any accumulations of hydrogen that would burn.

So the last I remember talking to the Program about ET [External Tank] icing and foam insulation, I guess it was still a Program Requirements Control Board at the time, a PRCB, that baselined I think it was about 1,300 pounds of additional foam insulation on the Tank to preclude icing under the particular natural environments that were at the pad here at Kennedy and at Vandenberg.

I was never welcome in Marshall after that. Actually that's being a bit facetious. The Marshall guys were not a great fan of having an additional 1,300 pounds of insulation on their vehicle. Basically I parted ways with that particular study of hardware development at that time because the Program had recognized a requirement that it had not had since the initial baselining. I went on to other work. The Tank guys went on to other work.

The Tank guys I have to recognize, as the Program moved along, did an absolutely fantastic job of managing the weight of their element downward. I believe the baseline Tank weighed about 80,000 pounds, and I think the ET-[96]—it went from the baseline Tank at about 80,000 to about 70,000 [as] the Lightweight Tank. Then the Super Lightweight Tank was like about 60,000 or even less. To take that much weight out of a flight weight structure already is just amazing. My hat's really off to those guys. They did a fantastic job in controlling and reducing the weight with innovative structural and material changes in the Tank. So they got my 1,300 pounds back easy.

ROSS-NAZZAL: How did you work with the folks at Martin Marietta and Marshall? Were you constantly traveling to Alabama and Colorado?

SHEEHAN: There was a resident External Tank guy at Downey, a Martin Marietta employee. He was the local project engineering guy, program guy, whatever you want to call it. He and I spent a lot of time together. Me trying to understand exactly what the configuration of the Tank was, and what our suggested requirements would do to the design of the Tank and the construction of the Tank.

I took I don't remember how many trips it was to Marshall. I remember going to Michoud [Assembly Facility, Louisiana] for the CDR [Critical Design Review] for the External Tank. I remember going to Eglin Air Force Base [Florida] and the McKinley Climatic Hangar [at Eglin] when we were trying to determine what the natural environments would actually do to a bigger than laptop or desktop size test specimen. I can't remember whether it was Martin built it or the labs at Marshall built a Tank that was maybe 15 feet in diameter and maybe at least the same, maybe 20 feet tall, insulated with urethane foam. As I remember, it had maybe some systems installed in it like a feed line or something.

We actually had that sitting inside the hangar attempting to validate the thermal models that the Martin designers had been using to predict whether or not ice would form under particular environments over particular parts of the External Tank. Actually it wasn't anywhere near a stretch of the capabilities of the hangar, because the hangar is big enough to roll a B-52 into it and put it down to minus 65 degrees with systems running, engines running. I think the temperature was maybe 38 or 40 degrees with a 15-knot wind blowing. Big fan over there. We had liquid nitrogen pumped into the building through the back wall of the hangar and into the Tank and back out. So we had much better than subscale development things that had gone on back in the labs that were a proof of concept of what they would do to preclude ice on the Tank.

The other thing, as a corollary to the fix-it on the Tank, at the time the Orbiter guys, especially the Orbiter TPS guys working with the silica tile TPS with the reaction-cured glass coating on it, they [had] a "don't touch me" kind of attitude. Almost as bad as the Tank guys were, "Well, I don't have a requirement to preclude ice." So everybody was very, very parochial.

One of the things that we didn't know is what would ice really do to an Orbiter tile. One of the things we didn't know was, well what really is ice like, the ice that forms on a cryogenically cool surface. What's its density? What's its typical size? Etc., etc., etc. Is it really frost that gets wet and slushy, or is it condensate that runs down over the cold surface and forms a really hard, 60-pound-per-foot kind of ice cube? What would all of those different things do to an Orbiter tile?

So one of the more interesting things that we did—we didn't want to get into a big expensive test program but we wanted to get some actual ice-on-tile experience. ET icing and Orbiter impact was principally an initial stage of ascent problem. So the vehicle isn't going much over a couple of hundred miles an hour. We didn't need supersonic things and that sort of thing.

I found out from some of my old buddies at KSC that Bob [Robert B.] Sieck, who was a weather man during Apollo, I think, as I remember the story, but had by that time gone into Test Operations down here at KSC. He drove a race car. I drove kind of performance cars. I had a Porsche 911S that I drove for years and years and years. So we hit it off. I can't remember who had the gem of the idea, but it wound up with ice balls and frost balls and slush balls hanging from kite string out at the SLF, a kite string hanging from a clothesline basically. Bob Sieck driving his race car with a TPS tile mounted on the roll bar into the hanging blob of whatever the test specimen was.

We learned what were the real-world reactions of ice balls, slush balls, frost balls on Orbiter tile. So that confirmed that yes, there was a real issue with allowing "theoretically forming" ice to occur on the Tank, because it would in fact damage the tile. The results of that were fairly well known because the tile guys, in their development program, were off doing tests of damaged tile. I'm not sure exactly, because I wasn't really involved with those guys at that particular time, but they were showing what could happen to the tile and to the underlying structure. Certainly one of the most dramatic test articles I ever saw in Downey was a piece of simulated Orbiter structure with a tile array on it and a missing tile that had been subjected to a wind tunnel test, probably an arc jet tunnel test. The damage to the vehicle structure made a very strong impression on anybody involved in the Program and confirmed that you didn't ever want to get into that situation.

It took about a year and a half I guess, before, as far as I was concerned, I was done with ET icing and the requirement had been established and I went off and worked other things. At the same time I was doing the ET work, I was also working in Orbiter systems. One of the fairly benign systems but one that was terribly difficult to get anybody to take seriously was the system which purged the vehicle of hazardous gases and chemicals pre-launch. In that same system they had the vent doors that you still see today on the side of the vehicle that open for launch to allow the air that's inside the vehicle on the ground to exit as you ascend. Conversely after you get through a high heating zone on reentry and you're ready to repressurize the Orbiter so you don't crush it like a grape since it's totally evacuated in space, the vent doors open and allow atmospheric air to come in and repressurize the structure.

Then along with that there's another aspect of that system. Since the vehicle was basically going to be kind of like an airplane that would sit on the ground, and exposed to rain and other types of precipitation. Since there was not a requirement to preclude water from getting into it, we had to figure out a way to get water out of it, either by statically draining it down through the structure and out the low points or by actively pulling it out of the pockets and places where we couldn't get drainage from.

That took a while to work that out also. The design guys were struggling for months trying to get their system designed. They really didn't know how much air conditioning they needed to provide and how much vent area they needed. Along about that time I'd gotten a transfer from the systems integration group I was in, to the Orbiter Project Office. So one of the first things I had to do there was to write—[it's] called an MCR. A Master Change Record, which really doesn't help much in the description of what it is, but it's basically classic project engineering kind of work. It's a document that you write to assign tasks and schedule and cost, if there's any involved, to gather requirements or design concepts, and lead up to a design change. That was the first MCR I ever wrote. It was MCR number 646. I think we're on 35,000 by about now so there's been a few changes to the Orbiter since my first MCR.

The other thing I did in that same timeframe is— this was back in the system engineering days—our group had the responsibility for establishing measurement instrumentation requirements, measurements on the vehicle, in the systems. Allocating, for lack of anything else [to call it], a count of how many measurements which element could have, because we had to integrate that with the capability of the instrumentation systems that were on the Orbiter and the telemetry systems that sent that data to the ground or recorded it, depending on what kind of instrument it was. So I had a lot of interesting work in how you design instrumentation systems for the location and layout of where the actual instruments were on the vehicles to gather particular data.

Most of the stuff I was interested in at the time, or we were interested in at the time, was not necessarily the performance data on particular Orbiter systems, whether they be propulsion or life support systems, reaction control, or flight control. That's the basic temperatures and pressures and positions of the actual hardware in the Orbiter, in the Tank, or in the Booster. That was left to the designers of those particular systems. But where you had surface temperatures and pressure measurements on the outer skin of the Orbiter or on the Tank, we pushed through the requirement to get the Ascent Air Data System on the top of the External Tank, the little pointy thing which is now the lightning rod, originally started out as an air data system that gathered air data from the nose of the Tank. I learned a lot from the folks that I worked with at the time there in Downey on doing that kind of work.

Since I had been a KSC guy, since I had been a launch site guy, the other thing that I wound up doing was working as an—jumping back to my job as project engineer—interface to the launch site. We had a fairly broad spectrum of things we were interested in and worked on. Contamination control for payloads. I always laugh at the naive little cartoons, conceptual drawings that were from back in that day, basically a bare Orbiter in a big hangar. Somehow the payload bay doors are open. There's five or ten or fifteen guys walking around in bunny suits. That's ground turnaround. Today when you go over to the Orbiter Processing Facilities, when there's an Orbiter in them, you're hard pressed to even be able to see the vehicle inside the access stands that are necessary for gaining access either directly to the vehicle or to the inside of the vehicle to do all the turnaround operations.

So I worked with a whole bunch of different people, most of them materials and processes type people, who had experience in clean rooms. Of course even I had worked in clean room environments here [at KSC] on the lunar program. It's necessary to keep particulate and hydrocarbons and other things out of various systems, because they can cause either damage or violent reactions with the media, whatever it might be. So I knew a little bit, just enough to be dangerous, about clean rooms. We had to come up with concepts of how you would process an Orbiter in the Orbiter Processing Facility [OPF] that also needed to be a class 100000 clean room, which is a pretty good clean room, that the payload community was demanding of the system.

[This also] worked back to establish some of the purge requirements, both inside the vehicle and from the facility, and ways to control to a higher level the contamination, mostly airborne particulate kind of stuff, in the payload bay, both in the OPF where the first payloads were installed and removed, and at the pad. That design, the basics of the Payload Changeout Room that's on the Rotating Service Structure, and the purge systems that go to maintain cleanliness of that room for the highly sensitive payloads, some of which we can neither confirm nor deny ever flew.

[The design drivers for these systems were] typically classes of payloads like Hubble [Space Telescope] that are highly contamination-sensitive. The success of those is based on maintaining cleanliness around them on the ground and the facilities and the purge media that's provided for them. So I got involved in a lot of that too.

ROSS-NAZZAL: Were you working with DoD [Department of Defense] and some of the Hubble people at that point?

SHEEHAN: No. That was way before I think Hubble even was a gleam in somebody's eye. We were working with typically the folks who had experience. Of course there was a long history by that time, mid '70s, of both those kind we can't talk about and other payloads from across the river, launched out of Cape Canaveral or launched out of Vandenberg. So the industry knew what was required in terms of environments. We struggled to provide lower level requirements on ground systems and airborne systems that would allow us to meet from an integrated standpoint those kind of environments, which we knew the industry, the communications satellite, the observation satellites would need to maintain their functionality on orbit after being processed on the ground in those kind of environments.

What else did I do?

ROSS-NAZZAL: You told me on the phone that you discussed which [direction] you were going to put the Orbiter on the pad.

SHEEHAN: I had a peripheral association with that. For some reason which I don't understand, if I remember correctly in the original Rockwell proposal, we had the Payload Changeout [Room, PCR]. I think it was our idea. You always know a lot better than the guy who actually owns the hardware which way to do something. I've found that bouncing from coast to coast in this business. The guy on the other coast always knows your job better than you do, whatever it might be. Anyhow, the guys on the West Coast thought it was absolutely obvious that the Apollo/Saturn pads ought to be modified with a fixed tower on the north side of the pad, straddling over the flame trench. Up in that tower you would have—I think it was called—I was about to take credit for that but it was much before I was there, a "file drawer" PCR. So that it would slide in and out, translate in and out of this fixed tower. Of course the payload bay doors being on the top side of the Orbiter where it was a lot easier to exist thermally, that required the tail of the vehicle to be north when the vehicle was at the pad, i.e. "tails north."

So the KSC ground system design guys, whose job it was to implement the design of the ground systems, didn't like that idea at all. I'm not sure I, even to this day, can understand exactly why. I think they were worried about the ability to build a structure that would bridge across the flame trench and then be able to support the kind of loads that the tower would impose on the ground interface or the foundation interface.

Their idea was basically what evolved into the Rotating Service Structure and the Payload Changeout Room that is today at Pad A (and today at Pad B, has just been recently demoed and pulled down). I remember the arguments, the honest technical interchanges, you know those, they sound like arguments a lot, about which was the better way. That you weren't considering this, and you haven't considered that. Back and forth and back and forth.

The proponents of the "tails north" lost the final battle. The proponents of the "tails south" are in fact what you see at the pad today. The structure that has to rotate across. I think actually if I remember—which I don't very well—that was the main reason the folks in Downey wanted the tails north with the fixed PCR at the back end, because they couldn't figure out how you would actually bridge across the flame trench. Where the Rotating Service Structure rolls around now and rotates across the trench on its own little dedicated [railroad] track out there.

I also don't remember how we had proposed—we in Downey, I hate to include myself in that group sometimes. One of the hats on my hat rack is a blue hat that says "Downey" across the front, because some of my friends in Downey had to remind me after I moved back to KSC, "You were a Downey guy." Anyhow, I don't remember how the payloads were actually installed in that Payload Changeout Room at the north end of the pad. All that kind of stuff was designed not to the nth detail but certainly conceptually; that's the kind of work that was going on in Downey and at KSC during that period of time in the mid to late '70s, early to mid '70s even.

I remember one day I was just walking down one of the hallways, and this was early on, so it was a formative time when I was out there. I was [29] or [30], I guess, at the time. There was a cluster of structures guys around a drafting table. There [were] still drafting tables and number two pencils, or at least number two lead and lead holders, and triangles and T squares. They were discussing what the aft attachment, that structural attach of the External Tank to the Orbiter—it's the great big huge truss structure that's at the back end of the Tank that winds up in 11-inch-diameter balls on that structure, and then the Orbiter sits down [on them] with the mating sockets and a two-and-a-half-inch bolt [which] goes through [them]. Well, at the time there was some concern.

The original design was not a spherical one at all; it was more of a conical structure with flats on the sides of the cone. I think the idea at the time was that the conical structure with the flats on it provided a more generous load path [for] the "push" that the Orbiter was exerting on the External Tank. It was a simpler structural [solution to the] problem. As the design of the mated Shuttle was maturing, the separation dynamics guys realized that when it came to separation, the Tank and the Orbiter, which are basically "centerlines parallel" as it ascends, [but] as you separate, the Orbiter peels off of the Tank nose first. Once we got cameras on the External Tank late in the Program, that's probably the biggest lesson learned that future programs should have. Put cameras on the vehicle from the get-go. You can learn a lot from just looking at pictures.

You see that today. As the nose comes off, it peels off the Tank and thrusts away from the External Tank. They were worried that that conical shape, which basically went up into a conical hole in the Orbiter, had very little flexibility. The Orbiter would have to fly in a pure plus-Z maneuver, which is basically keeping the centerlines of the Tank and the Orbiter parallel. Then you got into off-nominal separation. You get into things where you may get into recontact and whatnot. So right there I spent probably no more than four or five minutes watching these guys. If you think about what should a bunch of guys designing a space vehicle look like in call it 1975 with pencils and quadrille pads, that's the way it was. They were just drawing away. Say, "Well, look, this happens. What if we did this or what if we did that?"

A guy named Vince [Vincent A.] Weldon actually was the guy who did that. He was the head of the aft fuselage design, I think, at the time. He said, "Gee if we just had a spherical ball that the Orbiter sat on, you could separate nose first and get the vehicle rolling off the back of the

Tank. Those spherical balls would just let the Orbiter pivot around them. Then you could separate off there. Problem solved."

Everybody said, "Yes, that's true. Oh, okay, we just designed the aft attach interface." [Those are] some of those moments that you remember.

I'll give you another one. I remember I often was in engineering review boards, either as spectator or presenter; mostly spectator, infrequently presenter. I was in one one day when they were discussing the design of a display in the cockpit for the crew to use. John [W.] Young was there. The particular display was for something during RTLS [Return to Launch Site abort]. I don't remember the specifics of which display it was and what the various design concepts or choices or proposals were.

They went through all the various different presentations. Ed Smith was the Chief Engineer for Rockwell. Aaron Cohen, I think, was still the project guy from JSC, the NASA guy from Orbiter Project. He was there for that particular thing. Ed and Aaron couldn't come to a solution so they turned to John. They said, "John, what do you think? Which display would you rather have?"

John said, "I'm not sure, because if we ever do an RTLS I'm going to be doing this." He put his hands over his eyes and went "aaa" all the way down. So that's the kind of things [you remember].

Another guy I worked with—you wonder what's wrong with these people sometimes. There was again an avionics thing. A fellow that worked down here on Apollo actually, Paul Rupert was his name. He had gone back to Downey before me. I didn't know him when he was down here, but he was down here, worked Spacecraft. He was giving a presentation on some avionics thing, probably on the size of the instrumentation system or something like that, because he worked a lot of that kind of stuff. He was in the same general area I was, [but] worked for a different boss. We both worked for the next level big boss.

He had his presentation going, and of course none of this on computer-driven displays or any of that kind of stuff. This was back when you had transparencies and viewgraphs. Everybody had to have viewgraphs of their typically hand-lettered briefing charts back in the good old days. I guess by then we were starting to use—how did we do them? Did we use typewriters with big letters or something? Anyhow, doesn't matter.

He was giving his presentation. Had a pointer. Everybody had the wood pointer with the rubber tip on the end of it. He's in the midst of this presentation. Again Ed Smith and Aaron or somebody, the big guys at the center of the big table, got into a discussion on some minor point. Rupert was a little older than me but not much. He takes the pointer and goes whack, whack, whack, whack on the table. He says, "Wait a minute, I'm giving this presentation, not you guys."

They jumped to attention, leaned back in their chair, "Go ahead, Mr. Rupert, continue." Just one of those little briefing techniques you probably don't read in the textbook on what's the best way to go about maintaining the attention of your audience. Anyhow, [those were the] kind of experiences in Downey at the time.

ROSS-NAZZAL: Tell us about moving back here to Florida and what you were working on when you arrived.

SHEEHAN: [I was in California] almost five years, not quite five years, I went out in January '73, and by the end of '77 we had hardware a-building in Palmdale [California]. I unfortunately didn't get the opportunity to spend much time in Palmdale. Went up for rollout of *Enterprise* when it first came out of the hangar. My two kids by then were three and four, two and three, something like that. The organization was building down here [in Florida], because of course at that time we were supposed to have flown the first flight in March of '78. That was the Program date for years and years and years, although all the elements were having their problems. The Rocketdyne engine guys were having problems with things staying together. The Booster guys had problems with the combustion instability and chugging in the Booster. The Tank guys were struggling to get Tanks that actually had the same thickness foam on them. The Orbiter guys were struggling with the weight of the vehicle.

In fact *Enterprise* was built and delivered. I think it's a little bit of history revisionism or whatever it's called, where you decide later on what history really was rather than what really happened at the time. The performance requirements on the vehicle were such that the structure that we built *Enterprise* out of couldn't ultimately meet the performance requirements.

The idea always had been that we have a vehicle that was stripped down for the approach and landing tests, the gliding tests, the separation tests from the 747, with and without the tail cone attached. We would use that vehicle for the aerodynamic test program at Edwards [Air Force Base, California], and then it would go back into Palmdale to modify it back up to orbital flight capability. Between the time that *Enterprise* came out of the hangar—I'm sure it was known well before then—and we got *Columbia* designed and built, the Program realized it would be too much work to modify *Enterprise*'s structure to allow it to go into orbital flight and meet the 65,000- and 32,000-pound payload requirements of East Coast and West Coast respectively.

So now you only can find that *Enterprise* was never intended to go into orbit. It was always an aerodynamic vehicle. That's not exactly as I remember history, but then I didn't take good notes I guess. Anyhow, the entire Shuttle Program hardware delivery guys, including KSC and the facilities and the processing areas that would be used for the various elements, were behind schedule.

In late '77 the family and I went up to Edwards to see the first free flight test of the Orbiter coming off the back of the 747, another lasting memory. We're in the desert, Edwards Air Force Base in the middle of the Mojave Desert. We're all lined up, parked in our cars, on the hill. There's some typical California kid next to me in a big fancy pickup truck and a ski boat. I'm not sure exactly where he was coming from or where he was going but he was going to watch the first Shuttle Orbiter make an aerodynamic flight that day with that vehicle.

So we watch that. I think we went back to the LA [Los Angeles] Basin for not very many days or weeks, and then we headed back across country. Some of the guys, who had worked here during Apollo and had transferred back to Downey before me, had transferred back to Florida again before me. I was going back down there to join them. The same big boss, Bill Edson, who had requested me to come out and work on integration stuff, was the guy that was heading up the organization down here. So I came back, and we worked.

One of the real shortcomings of the Shuttle Program, and another one of those hard lessons that needs to be learned by the next project, whatever it might be, is that there was very very very little integration of requirements between projects. Specifically what I mean is that as the Orbiter Project recognized that particular pieces of hardware may have failed qualification testing or they just didn't work, and modifications were engineered and new hardware was built and delivered, they did that almost in a vacuum of the particular project, typically Launch and

Landing KSC guys, what they needed in order to make the hardware change. Typically everybody thinks "Oh, I'm going to make a change to the hardware. I need an engineering order." Well, along with an engineering order you may need test requirements. You may need Interface Control Document [ICD] changes, because you now need different services or fluids or physical interface to the ground system.

Ground Support Equipment [GSE] may have to change the box, the electrical, fluid, structural thing on the ground. You may need flight software changes depending on if it's an active component in the vehicle that depends on the computer interface to work. [That] may have to change.

Nobody had a system which accumulated all these various elements of a change together so that the poor engineer at KSC who was responsible for implementing the hardware change could say, "Here, Mr. Software, you got to do this; Mr. GSE, you got to do this; Mr. ICD, you got to do this; Mr. Facility Guy, you got to do this. Mr. Test Requirement, you need to put this in the test procedure so when we check it out it's got the right requirements in it and you're looking at the right leakage or voltage or temperature or pressure or whatever the change had to do."

So I knew about that kind of stuff from my experience in Saturn. The guy I worked for, Glen Torrey, [also] had done similar kind of things on Apollo. We knew what we at KSC as the Launch and Landing guys now needed from the various Projects. This wasn't a thing that was unique to Orbiter. All the other elements had similar kind of things. We struggled mightily for a couple years first off trying to get the flight hardware guy, who actually designed it [to provide the other elements of the change]. He didn't care about another vignette from an Engineering Review Board out there. I remember "Oh, well, we don't know how to do that exactly, but we'll let the Cape guys worry about that." It was kick the can down the road. "I'll change my hardware and make it work." The guy at the launch site or the processing site can go figure out how to process it, how to launch it, how to recover it, or how to do whatever it is you had to do because the designer really didn't know how to do that right then.

That by the way—personal opinion—is part of the problem with the Shuttle Program. Many, many, many times I remember, "We'll let the guys at the Cape figure that out." The guys who designed the hardware weren't responsible for assuring that the hardware could be processed and launched in the amount of time that the Agency was publicizing as [to] why Shuttle was going to be so much cheaper than Apollo.

They weren't responsible for making sure that the processing timelines, which fundamentally sold the Program, could be met. It wasn't their job. It was the guys at the Cape's job. Now obviously when you're designing a spacecraft or designing any product it needs to meet the basic functionality requirements first. It doesn't do much good to design a rocket that can't lift off the ground because it's too heavy for the thrust that the engine systems give it. By the same token, if your design of your hardware is so expensive to utilize that it costs—pick a number on what it costs for Shuttle to fly a mission; it's either $250 million or $1 billion. I'm sure there [are] people that can prove either number, but without argument it's expensive to process Shuttle. My opinion is it's expensive to process Shuttle because the guys who had to design the flight hardware weren't responsible to also demonstrate the processing of that hardware within the timelines that were allocated to meet the mission model, which ultimately reflected in the dollars per pound to orbit figures that the Agency was quoting.

ROSS-NAZZAL: Did you actually think at the time when you were working on the Shuttle Program that you could see 50, 60 launches a year?

SHEEHAN: I absolutely, positively knew that we would never ever make the 160-hour turnaround. In [the] Space Shuttle book [*Space Shuttle: The History of the National Space Transportation System*] Dennis [R.] Jenkins [shows] a pie chart of the allocation of the two-week turnaround with little cartoons of what's happening to the Shuttle parts and pieces. The Orbiter lands and that's about a ten-minute slice. Then the Orbiter [is] processed in the OPF, and that's about a two- or three-day slice. We absolutely, positively knew that that would never happen.

We all did "wink-wink," "nod-nod," "yep sure," that's the timeline. But that's the timeline that was required to get the mission model to get the launch flight rate to get the cost per pound figures that the Agency was using with the Congress to show how cheap and efficient Shuttle was going to be.

We got the magnificent flying machine part really well. We didn't do too well on the processing and turnaround times and the expense involved in doing that. I remember a lot of times where you'd hear, "We'll let the Cape guys worry about that," whether it was a test requirement or how to interface with a piece of hardware to do a checkout. That wasn't their priority as designers. Their priority as designers was to get a piece of hardware designed which would fly to orbit like it was supposed to do.

ROSS-NAZZAL: Tell us about being vehicle manager for *Columbia*. Were you its first vehicle manager?

SHEEHAN: To have a little bit of continuity in the story, Glen and I stumbled [around] and put this change processing system together. When we were done with that, I then got to work on the vehicle, the first Orbiter that was delivered to KSC, *Columbia*.

It was delivered about when the launch was supposed to occur, as I remember, March of ’78. We didn’t launch of course until April 12th of ’81. So there was a lot of time to work vehicle processing problems, modification, implementation problems. So I left my job, or left the business system that we had established for working modifications, whether they be hardware, software, test requirement, [to others in the office] and [started to] work as the vehicle manager.

Even today, in a different company and a different organization, they still basically have the vehicle manager position. Typically the Engineering organizations are very stovepipey. They’re typically organized as fluid systems and structural systems and avionics systems and Thermal Protection Systems for Orbiter. There’s very little communication between those stovepipes.

Now as you get up into the management structure of those stovepipes, ultimately there’s typically a guy at the top that’s a Chief Engineer or Director of Engineering or some kind of majordomo up there. But there’s very little communication between the groups at the working level.

So what the job of the vehicle manager was is to provide the interface between the Operations guys who are laying out schedules of what work has to do be done [and] when in order to meet particular milestones by interfacing with the Ops guys that set up those schedules and track and revise those schedules as needed [and the Engineering teams]. The job of the vehicle manager—or it may be called a senior engineer or the vehicle mother or father—the job of that person is to interface between the Ops guys and the Engineering groups to make sure the appropriate priorities in Engineering are established and are understood so that the operations schedule, tasks on that schedule, can be supported and completed on time.

That's the day-to-day [stuff]: what does it take to recover the vehicle, safe it, inspect it, download all the stuff from last mission, upload the new stuff, do the new checkout that's required, and process the vehicle on to the next stop in the flow. The vehicle manager also has to worry about modifications that have to be done. Unfortunately, I have no earthly idea how many modifications we did on *Columbia* for the first flight, but I'm guessing it had to be thousands. There were lots of hardware at the time which wasn't meeting its hardware development schedules either because it just wouldn't work or because it was slow in getting it to work.

There was some hardware that we'd contract with vendors to deliver a particular piece, like a nut or bolt or simple little piece of hardware, and it wouldn't meet its specification requirements. It was too soft or too short or too hard or too long.

It wasn't what we needed. So in each one of those cases the authority from the customer, the Orbiter Project customer, the NASA customer, the change authority was in one of those Master Change Record things I told you about earlier, the MCRs. Some project office guy in Downey would have to write an MCR and say, "Okay, we've got to go get a different bolt from a different vendor. We got to go build a different piece of hardware or a different system, a different component." Each one of those things would then come down here with a thing called a mod [modification] kit which was the new piece of hardware, whether it was a nut or bolt or flash evaporator or an APU [Auxiliary Power Unit].

The vehicle manager would be one of the first guys down here that would be sensitive to that [change] by communicating [daily] back with his counterpart on the West Coast. We'd know that component X flunked or the bolts were the wrong thing or the wire was not insulated properly or whatever the problem was. We'd know that was a forthcoming change. We'd go to the Ops guys down here and say, "Hey, we're going to have to change the whizbang." Whatever it might have been. "There's a new mod coming. So we need to work that into your schedule. Maybe you don't want to do that test today because next week we'll give you a new piece of hardware which will invalidate all that testing. Maybe you want to do the test to make sure that everything else around that piece of hardware works like it's supposed to work. Then we'll repeat the test with the new piece of hardware after we put that in."

Those were the kind of things that went on on a daily basis during STS-1 processing with *Columbia*. It was a very, very interesting—challenging—but very interesting job. The best job I ever had. You had nobody working for you. You were *the* guy responsible to make sure everything worked. If it didn't work, then the head guy was going to come to you and find out what did you screw up that the right decisions weren't made early enough in order to accommodate whatever change was going to happen, which rolled downhill into some schedule impact.

Part of that job also was getting the engineering requirements, all of them: the hardware change, the test requirement change, the software change, the GSE, the ground, the facility changes, the ICDs, everything. Putting that package together, giving it to the engineering group, who was responsible to go implement that change in requirement or hardware or test or whatever it was.

The engineers would go prepare implementation paper. Of course everybody used paper then, handwritten with a black pen. Press hard, you're making three copies on this triplicate form. I was responsible to get those requirement packages out to the engineering groups that had to go implement them and then collecting their work paper and taking it to the change boards. Mainly the change board we had, because the vast majority of the stuff we did was hardware changes which had very few test requirement or software changes associated with them, but there were some.

So I was the Rockwell guy that was responsible to pitch, to receive approval from the authorizing Agency. Pitch. We had a site boss that [said] "I don't want you guys using pitch. That's like you're trying to convince somebody that you're not doing something wrong."

We had to pitch the changes to the two major customer guys that were here: the KSC head of the vehicle processing organization, the local NASA guy—that's when we were still here working as a processing contractor in the early days—and the JSC resident rep, who was representing the NASA Orbiter Project Office at KSC. So I'd be responsible to know what the change was that we had, why we were making it, what the impacts of that would be in terms of hardware and software and test requirements. That's why it was so important to develop that business system ahead of time.

So when they said, "Isn't this going to change test procedures?" You had to have an answer other than "Gee, I don't know." I've been there; I know that answer very well, but only [used it] once or twice before I learned [to come with the correct, complete one].

So I would pitch the change to Charlie [Charles B.] Mars, who was the NASA KSC guy, and Archie [E.] Morse, who was the JSC resident office guy. I don't think [I'm] overstating it, [but] we had a wonderful rapport together. We understood what our jobs were; both Charlie and Archie were old-time NASA guys that had come up through their respective organizations. I think that was probably the [same] jobs they had during the Apollo Program. Both of them were Apollo Spacecraft guys.

We had a wonderful rapport together. We knew what we were supposed to do. Ninety-nine percent of the time I was prepared. It's always good to be prepared when you're trying to convince somebody to do something. That job forced me to know how all the little pieces fit together into the big picture because those guys were experienced enough to ask questions like what's the impact to schedule; what's it going to do to test requirements; why haven't I seen software changes that go along with this; you're adding a new component that has a new measurement on it, where's the change to the data bank which tracks all the instrumentation? It was really challenging and really satisfying kind of work.

I'm sure I'm only remembering the good times. But boy, I can't remember right off the top of my head where Charlie or Archie [ever] said, "Absolutely positively no, get out of here," [where] I didn't suggest ahead of time that maybe that was the answer that they should have. I remember a couple of those where it is typical. Again, a lesson learned kind of thing for a future program: the payload bay door linkage has little things on the ends of all the pushrods in the mechanism called rod end bearings. It was a case of we bought a component from a vendor and the specification requirements on the component required an ability to withstand a particular load through that bearing. The acceptance tests of those didn't meet it. It was way off. So my friends in Downey invented this new MCR and designed or procured new parts and accumulated a mod kit and sent them down here and said, "Oh, you got to." Gave us engineering to accomplish the [switch and] changed all those rod end bearings out. Fortunately [this] was another case where I'd done my homework.

Charlie, I think, asked, "Why are we doing this?"

I said, "Same story. Part received from vendor didn't meet the requirement."

He said, "I guess we got to go change it."

I said, "Not exactly." The spec [specification] requirement was to meet a 1,000-pound load before you push the bearing out of the rod end. The vendor had delivered ones that would only withstand 100 pounds. You say, holy cow, it's only making [X %]. I was—one of the rare times, pat myself on the back—smart enough or suspicious enough to go call the guys in Downey and ask them just exactly what did that part see in flight.

They said, "Oh, it's only seeing about ten pounds." So we had a part that was supposed to meet X. It only met a tenth of X but that was ten times more than Y which was the load it actually saw. The job to do this change, you basically had to disassemble all the drive linkage in the payload bay doors and then do all the rerigging. It would have been weeks if not months to get that done. I suggested, "Perhaps you gentlemen, as the NASA representatives, don't want to approve the implementation of this because we have a margin of ten to one on the actual loads. We really don't need to change the existing hardware." We certainly need to change downstream because somebody else, somewhere else on the vehicle may decide to use that same piece of hardware in a totally different system. They're looking at the spec, and it says it's good for 1,000, so maybe their [flight] load was 900 or 1,000.

So I said it's fine that they provide the engineering and change the drawings and provide new hardware in the logistics systems but we didn't have to take the two weeks or three months or whatever it was going to take to do the modification to the actual flight hardware on *Columbia*. They were going to pick it up in line for the next vehicle that was to be delivered, but it wasn't necessary for us. That's the kind of thing that the design side of the Agency didn't tend to worry about. "Oh, this is wrong, I'll do the good engineering thing; I'll fix it." But they didn't consider what the implementation of the fix would do to the processing schedule. We were already two years down; we didn't need to be another year down doing all this "nice to have" things that aren't really necessary.

ROSS-NAZZAL: Tell us about the tile and the headache that it posed for you as vehicle manager.

SHEEHAN: In truth, the tile was such a problem on STS-1, and it had so many hundreds of people working on it, I didn't worry about it too much. Let's see, [did] he start out that way? I think he did. The supervisor of the tile group, at least the engineering group, was a guy I went to college with and worked in the propulsion group on the S-II stage. He took over the tile organization. As I remember he was in propulsion or something on the Shuttle side. The site director down here was impressed with his ability and wanted him to work tile. He had the biggest organization of engineering and quality and tech people trying to solve problems. I think every one of the 32,000 tiles that were on *Columbia* had something wrong with it. As long as he had that force of people working, when he said they were ready, I figured they were ready. I didn't need to worry about helping him or getting personally involved with that.

As it turned out, as we approached OPF rollout for the first time, there was a monumental amount of work paper that [we handled]; we got a whole bunch of transferred work from Palmdale. I think every tile was removed and installed a couple times while the vehicle was here. So there was just a horrendous amount of paper that had to be all reviewed. Each piece had to be reviewed and verified that it was in fact complete and all the work was done. Just the clerical work of doing that took another army of people. It certainly seems like it was more than a week [before rollout], but maybe it was only a week. Everybody in engineering and just about every other organization that wasn't already working on tile got handed a piece of paper and [were told], "Here go verify this work is done and it's completed and it's closed up through the quality assurance systems." So that's all a blur to me anymore because we worked so hard and for so long to get [finished.]

Every day the rollout day out of the OPF was coming closer and closer. Everybody kept saying, "Yes, you are going to make that rollout date." So it was a very highly pressure-packed few days or weeks, whatever it was, in making sure all that paper was properly accomplished and closed and in the appropriate accounting systems to make sure that we knew in fact we had done everything we needed to.

ROSS-NAZZAL: Tell us about that first launch. What are your recollections? Or the first attempted launch even. Did that pose any challenges for you as vehicle manager?

SHEEHAN: Not really. When the vehicle got out of the OPF 90% of my work was done. Very little to do in the VAB (Vertical Assembly Building) where the Orbiter and the Tank and the Boosters all came together. Or [more correctly], the Boosters started and the Tank came to them and then the Orbiter came to the set.

Certainly [now] at the end of the Program all that work [is] very well understood, [is] very repeatable. It [takes] the same amount of time to do it. [But], in the very early days it was a little different because we did a lot more testing, a lot more inspections. It always amazes people today who joined the Program late, that we [once] ran APUs powered by decomposed hydrazine in the OPF, inside the bay. Today you can't do that. I said, "You may not be able to do it today but we certainly did it then." We installed ductwork up through the structure and through the roof of the OPF and ran the APUs and the hydraulic pumps and moved aerosurfaces around just like we had good sense. Too many people today are frozen by the current interpretation of safety and other requirements that preclude them from doing stuff like that.

In any case, to get back to your question, the VAB mating the vehicles correctly was the biggest thing happening over there but that was pretty much controlled by the structural, mechanical, and propulsion guys. Avionics had a little bit of work to do there mating the umbilicals for the first time. [We] did a lot of testing. Then rolled out to the pad. Did more testing out there. Serviced the storable propellant successfully the first time. Had a little bit of a problem the next time around.

I'm not sure that anybody actually thought we'd launch the first time through. I had been through all the launches of the Saturn V either as an off shift guy in the control room or a launch crew. So I had a little bit of experience about how complicated and how difficult it is to get all that hardware to work the first time. We cut off for a general-purpose computer problem as I remember. Came around the second day and zip, zoom, there it went, all the way down. "Well, something's got to happen now. Something's got to happen now. Something's got to happen now." Went, marched right down through T-zero just like we knew what we were doing and launched. Obvious exhilaration in launch, which is why this business is so attractive to the adrenaline junkies that work in it and can [make up for] the rest of the things that come along with that.

The aural and physical sensations that you got from Shuttle were quite different from Apollo/Saturn. Apollo/Saturn was loud and rumbly and slow and majestic to take off. I was not in the firing room for the first countdown; I was outside. As I remember, we were over on the northeast corner of the VAB. The noise was significantly different. Everybody says, "Oh that's the Boosters making that sound." I don't know how you separate which piece of the hardware is making which particular noise when it's 180 dB [decibels] or whatever; it is *loud*. I know I turned around a couple times just to make sure the siding was staying on the side of the VAB. It was significantly louder. It was a different kind of noise. I always tell people if you've never seen one or heard one before it'll sound like [beats on chest] on your chest. The pressure waves or acoustic load is bouncing off your chest. Of course that's rattling all the structure that you may be near.

They went up and flew around and landed. Another fond memory is John Young coming down the steps at Edwards and almost dancing around the vehicle. He was so visibly excited and happy at the performance of the vehicle. I don't know, maybe given the other story about what he was going to do during RTLS, maybe he was just so happy he lived through the experience that he was elated.

I still get a kick out of watching that little snippet of film. I guess it's film. I'm not sure we had video in the day. Of he and [Robert L.] Crippen doing the walk-around on that first vehicle recovery. He was just overwhelmed I guess.

ROSS-NAZZAL: How long did you serve as vehicle manager?

SHEEHAN: Well, I skated along in the best job I ever had for years and years and years. Funny how the community is so small. Back on Apollo, the Spacecraft guys had some problems with the propulsion systems on the spacecraft. The site director at the time Tom [O'Malley] wanted one of those hotshot S-II guys to come down and help his poor propulsion people solve their problems. So I was the anointed "hotshot propulsion guy" that got sent down to Spacecraft. For the first time I met a fellow named John Tribe who had responsibility for the SPS, the Service

Propulsion System, the big engine on the back of the Service Module and all the Reaction Control jets on the Service Module and the Spacecraft.

Thinking back over the years, I'm always amazed at how—courteous I guess would be the best word. He's inherently a gentleman, but I can't imagine if I was up to my eyeballs in alligators I wouldn't want some hotshot kid coming down and telling me how to drain the swamp. He was very, very accommodating and friendly to me. Of course they were doing everything right that they had to do. It was just like any other accident. All the holes in the Swiss cheese lined up, and [they] ran into a problem.

Terrible design of the hardware, by the way, and its unforgiveness [to] minor errors in processing that you make, typically. About 20 years later, John is the head of Engineering on Shuttle. He says, "Okay, Jerry, it's long enough. You've been vacationing as a vehicle manager for long enough. It's time you get into management." There were a couple guys that had left the Program. John wanted me to take over the Project Office and all the rest of the vehicle managers. That was in the mid '90s I guess.

Then I had an opportunity to pick as my successor as the vehicle guy, curiously enough, another guy I'd gone to school with at Gainesville and had worked on S-II with [Al Seraphine]. So he had a long track record that I was very familiar with and knew he was eminently qualified to do the job. So I had the opportunity to name him as my successor. I had then responsibility for the Project Engineering organization and the Configuration Accounting organization that was a little bit of a different slant on things than I was familiar with.

A number of years after that, as they always say on the resumes, I moved up through ever more responsible positions of management and wound up being director of Orbiter Engineering for Boeing, at least, at KSC.

ROSS-NAZZAL: What does that entail?

SHEEHAN: I always got to start out with a very complicated organizational structure discussion because it doesn't make any sense otherwise. The Boeing Company as the OEM, the Original Equipment Manufacturer, of the Orbiter through the years has wound up with a contract with the United Space Alliance [USA] organization. We are responsible for sustaining engineering on the Orbiter. There's the [Boeing] Orbiter Engineering part of that, and [we] are matched with a USA and of course NASA organizations behind [us].

We have [this] responsibility for Orbiter Engineering, [and] we [also] have a responsibility for Systems Engineering and Integration, and we [also] have a responsibility for Logistics Support. The Logistics Support is kind of part of Orbiter but not exactly. So it's easier to describe it as three different organizations. I [provide] under the Orbiter Engineering part of that [three-part] organization our product that we "sell" to our customer: Orbiter hardware and software systems expertise. I haven't tracked it probably for five years but the last time I tracked it my employees had on average 17 years of experience in Orbiter design or processing. So I have very, very senior, experienced experts in all the vehicle systems.

Our job is to support the processor, United Space Alliance, in resolving any design problems which they may have, or any problems which come up as discrepancies that have to be repaired not in accordance with a particular engineering drawing. Those things are called MRs (Material Review). Repair and salvage of the particular hardware is one way to think of it.

Then I have flight software experts that assist in any questions that may come up in that [area. These] organizations again are the traditional stovepipes: fluid, propulsion, avionics, structures and mechanisms, and handling. [Handling is treated as a "system"] because the Shuttle Program has a significant amount of handling [huge pieces of flight] hardware; we're stacking a 727, 737-size airplane on the side of a huge External Tank which is mounted between two Solid Rocket Boosters. So there's some pretty specialized hardware and techniques that go along with that.

Then I have the Thermal Protection System and materials and processing support people that go along with that. So we're the [design] experts. We're supposed to know everything there is that can possibly happen to the Orbiter in either a normal processing mode or in any kind of either hardware or test anomaly solving any particular problems that require our fairly unique knowledge of all the Orbiter systems.

ROSS-NAZZAL: When did that capability move from California to KSC?

SHEEHAN: In about 1995 I think. For a history buff I have a terrible time with [dates]. That [Christopher] Columbus guy, when was that, 1400 and how many? I have a terrible time with dates, but I think it was along about there, about 1995. The whole idea was to move the sustaining engineering capability—unfortunately we only did it with guarded success—to move it out of California. At the time at least the argument went that most of the new design engineering was done. We were sustaining rather than engineering new. We were sustaining the engineering. So it was to move either to Houston where it would be close to the Orbiter Project Office customer, both the NASA and the USA customer, or [KSC]. In particular systems like structures and TPS are the best two examples where it's highly unlikely that you're going to design new hardware for those systems, but you have lots of processing issues to deal with—

dings and dents in the structure or corrosion repairs you['ve] got to make. Or in tile you['ve] got gap fillers and putty [repairs] and the whole litany of other things that go along with [processing] TPS. In case of both systems, typically those are things you fix almost real-time on the floor (the processing area), wherever you might happen to be. So it made sense that that sustaining engineering group came down to KSC rather than stop at Houston.

Get them next to the hardware where they would do the most good. There were a couple other areas like our wiring experts that came down here. That was especially obvious when we had the loss of the AC power bus to the engines, which affected mainly the engines on STS-[93]. Eileen [M.] Collins's flight when we lost the power bus—one of the redundant power buses to the SSMEs because of a short from damage to wiring in the wire trays in the midbody, which kicked off a—we always called it wiring summer. We spent six months of inspection and repair in the wiring systems, the however many hundreds of miles of wire we have on the vehicle, to make sure that we didn't have any similar damage that could cause real problems.

Most of that [engineering expertise]—some of it was retained in Huntington Beach [California], but we got some of it here. The expert in wiring installations came here so he would be able to address the problems real-time on the floor. "Eyes-on" kind of thing. It doesn't do any good to have a fantastic expert 2,500 miles away when the problem comes up at 3:00 a.m. Sunday morning on the floor of the OPF. That guy 2,500 miles away is of questionable use, no matter how smart he is. That's another kind of lesson learned for future programs, that there probably ought to be a conscious decision by the program management that says gee, here's either traditionally the kind of things we have problems with, or after a flight or two or three or seven say, "Okay, we're continuing to have these kind of problems in processing and this kind of support is necessary, so we really ought to move that kind of support." If you can't move the entire design Agency to the launch site then you ought to selectively pick out the guys that can give you the most help in the processing and put them next to the rocket ship where they can do you the most good in fixing problems as they come up.

ROSS-NAZZAL: Do you think that was helpful for the return to flight after *Columbia* [STS-107 accident]?

SHEEHAN: Absolutely, yes. It's been my experience that you can't help but develop some relationship with people that you work with every day. If you have to wait, "Oh, I can't call Joe because he's not in for another three hours, and I got to leave early today, a half hour or so, to get my kid from school," you wind up with about two hours that you can talk to people on the West Coast. That's not conducive to really expeditious handling of issues and problems and solutions. So it really helps to have those kind of folks on site or readily available.

Even folks in Houston. You're still an hour away. Although we have wondrous video and photographic kind of capabilities now that we've never had before, Jerry Sheehan doesn't think there's any substitute for putting eyes on the hardware, boots on the ground, to figure out what's really going on. Hopefully the next programs will recognize that early enough to make enough of a difference early in the program.

ROSS-NAZZAL: Rebecca, do you have any questions for Mr. Sheehan?

WRIGHT: No, other than probably just something a little bit more generic. The years that you spent here. You mentioned earlier about having to start moving some things around. Are you planning to exit out of the Program as well?

SHEEHAN: About a year and a half ago when the Program was supposed to last only about four, six more months, I was ready to retire. The Boeing Orbiter Program Manager, (he and I again developed a wonderful working relationship early, years and years ago) said, "You are going to stay around to the end of the Program, aren't you?"

I said, "I was planning on retiring."

He said, "Gee, would you please, just for me, stay around?" He might not have said it exactly that way but that's the way I remember it. Stay around until the end of the Program.

I said, "Okay, John [Mulholland], just for you. Just because you're a nice guy I'll do that." That was a year and a half ago. Yes, along with the wonderful choice of parents I made, I made a wonderful choice of which program to follow when, and carefully calculated it so that it would be done when I was ready to retire. So I can gracefully step out of this job without affecting anything other than my own self. So that worked out wonderfully. Since I've been around this area since 1950, at least for the foreseeable future, my wife and I will stay around here. One kid is still in college. The other kids [have] jobs or jobs and family. All that is taken care of too. So it's not like "I got to stay around here because I'm 60 years old but my two-year-old has just gone into daycare." I know cases like that. Not mine, but cases like that. So yes, I'm pretty well set, if I have enough empty boxes to put all the memorabilia and other stuff in. I don't know what I'm going to do with it when I get it to the house though. There'll be some sorting of what's really important—well, everything's really important. Going to have to build another big room on the back of the house with lots of wall space I guess, just to hang stuff [on].

WRIGHT: Sounds like you'll have a project to keep you busy.

SHEEHAN: That's for sure. That's what the little red car is. That's in the garage with a fuel pump that doesn't work. So that's one thing [to fix]. The choo-choo train stuff has engendered an interest in building live steam locomotives, water and fuel and heat and exhaust and chuff-chuff sounds and whatnot. So I [also] do that [now]. Not to the level or extent I want to, but in about another two months that will change. Yes, it's been a hell of a ride as they say. Interesting, challenging. Few heartbreaks hither and yon. But for the most part I'm not sure I'd want to change much.

ROSS-NAZZAL: Well, thanks for taking us along for the ride. We appreciate your time today.

[End of interview]