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INTERVIEWED BY JENNIFER ROSS-NAZZAL
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ROSS-NAZZAL: Today is November 7th, 2007. This oral history with Bob Wren is being conducted for the Johnson Space Center Oral History Project in Houston, Texas. The interviewer is Jennifer Ross-Nazzal, assisted by Sandra Johnson. Thanks again for coming in today for a third session. You had mentioned before we turned on the recorder that you wanted to give a few updates from our last session.

WREN: Just a couple of comments if you don't mind. You introduced something that I had completely forgotten about on the 2TV-1 program, which was the patch, and the proud bird with the heavy tail. I had completely forgotten about that, and of course it had a roadrunner on it because Roadrunner was real popular at the time. So everybody was trying to wear those patches, and it was a lot of fun. But I appreciate you finding that, because I had totally forgotten about that, and I didn't see that in any of the stuff I poked around in, trying to find notes and so forth. [At the time, we often flew National Airlines and Continental Airlines ("the proud bird with Golden Tail"). Since the crew was "flying" 2TV-1 in the space chamber, it never left the ground. Hence the proud bird with the HEAVY tail.]

So then the other thing I wanted to say was that if anyone is interested in delving more deeply into some of these areas like we talked before extensively on the Apollo launch and boost environment simulations, and I had almost forgotten it, we had published some papers on that, and it may be in some of the notes. But it's in the 37th Shock and Vibration Symposium of

October '67. That was a session that was conducted by a Dr. Mutch from the Shock and Vibration Information Center at NRL, which is the Naval Research Lab in Washington [D.C.]. That was held down in Orlando, Florida. [Editor's note: these articles can be order by accessing the NASA Technical Reports Server: http://ntrs.nasa.gov/search.jsp. Links to similar articles authored by Wren are provided here.] We had a couple of papers in those proceedings that described what we did to do the simulations. So if anybody would like further detail, they could dig into that perhaps. Of course in all these cases of what we did, there's TRRs [Test Readiness Reviews] and there's test reports and so forth that are somewhere in the archives that one might delve into.

Another one I mentioned is the history book that NASA has published as SP-[4]205 *Chariots for Apollo: A History of Manned Lunar Spacecraft*. That was that book that I was bringing a couple of times. I didn't bring it today. It was published in 1979 by [Courtney G.] Brooks, Jim [James M.] Grimwood and [Loyd S.] Swenson and it addresses although very lightly 2TV-1 and LM-2 in there. So if anybody wants to delve deeper, why, those might be some references. So I just wanted to mention that.

ROSS-NAZZAL: Sure, absolutely, and if you'd like we can provide some links in your transcripts to the patch. Obviously we could provide that link to that page and to the SP. We can see if we can find those papers and maybe we could have them scanned and uploaded. That's really helpful, I know.

WREN: I don't remember who all authored. We kind of took turns. But I think most of the time on those Shock and Vibration Symposium papers it was myself, Wade [D.] Dorland and Ken

[Kenneth McK.] Eldred and there might have been a couple more. I don't remember now. But I know there was at least two papers that we generated, maybe three or four, I don't remember.

ROSS-NAZZAL: I think I've seen several of them that I had downloaded and read. Great. Well, good. I thought we'd talk today about your work with the Space Shuttle integration process, and I was curious how did you become involved in this project while you were working on Space Station, Space Base?

WREN: We kind of overlapped there on some of these efforts for a while. In about October of '72 while I was still I guess working on wrapping up some of the Space Station and Space Base studies that Rene [A.] Berglund was leading out of the Program Office, it became apparent that while the Shuttle was being designed and developed somebody better start paying attention to what it was intended to do. So I was asked to get involved in that.

What it entailed is the Shuttle was of course designed to be a reusable winged vehicle, but it's designed to carry payloads to orbit and in essence like a truck, a transport. Take payloads up and bring payloads back. The payloads that it was designed to accommodate were such things as Sortie modules, free-flying experiment facilities, unmanned satellites, expendable propulsion stages, reusable tugs, planetary probes, cargo modules, and of course the modular Space Station modules that we talked about last time.

In order to do that then we had to start doing two things. One, we considered any time we took up a chunk of something for somebody, we said that those were our customers. So what we had to do is provide some kind of information for the potential customers on what the accommodations would be in the Orbiter. So we developed all kinds of books and paperwork and so forth for the customer to be able to consult, and they would then know what the interfaces would be for their payload as it was located inside the payload bay or in some cases for small things in the middeck and so forth in the pressurized compartment of the Orbiter. Of course there was an integration and development office created, SPIDPO, Space Shuttle Program Integration and Development Office, with Leonard [S.] Nicholson, [Charles W. "Chuck" Pace, Glynn S. Lunney, Harold Draughan, C. Harold "Hal" Lambert, Lawrence G. "Larry" Williams, etc. and later Brewster H. Shaw and Tommy W. Holloway, etc.] and then of course different E&D [Engineering and Development Directorate] as well as Life Sciences and Ops [Mission Operations Directorate] and the usual support to support all these efforts. So I guess I became, for the Structures and Mechanics Division, the division manager for Space Shuttle Payload Integration.

So we defined requirements first of all. What is it that we had to create in the way of requirement? On the payload, to observe so that what was going to be offered by the Orbiter wasn't violated either in something that could be done or perhaps something that was not safe. So we spent a lot of time defining those requirements, and then we defined the interfaces like I said, and we came up with Shuttle service accommodations, we came up with core ICDs or interface compatibility documents, cargo accommodation documents. Then we started out as usual with a broad overview and then we started core-drilling down in more and more detail so that we could do two things, that we could feed that back in as a design driver for the Orbiter so we could provide those kinds of accommodations, and then also like I said that would be information for the customer. Of course we got in then to things like weights, sizes, envelopes, environments, loads, clearances, thermal, the usual thing, vibration, acoustic, pressure, solar, power, so on and so forth.

We ended up then with a whole series of payload accommodation documents for the customer and payload interface documents and books and so forth. It was quite a sizable effort to do that. But we also set up processes to control all this. We set up cargo integration reviews, we called them CIRs. Of course we still continued with the FRRs, flight readiness reviews. Set up also PIMs, payload integration managers, that resided in SPIDPO in the Program Office. Essentially what were we after?

What we were after was mission success and safety. Of course this is just like in previous programs, it's standard things for Mercury, Gemini and Apollo also -- but you want the mission, whatever it is you're trying to accomplish, to be successful, and you want the crew to be able to do it and the Shuttle to accomplish it, and mission success for the payloads and crew and Shuttle. But you also want safety. Since it's a manned operation, utmost in our minds always was safety of the crew and then of course safety of the Shuttle hardware; we didn't want to damage any of our own hardware, and then same thing for the payloads. We didn't want the payloads to damage anything or the payloads themselves to be damaged. Then in safety also on the ground. We spent quite a bit of attention being sure that safety of people and facilities and so forth on the ground were considered in what we were doing from a safety point of view.

We set up safety review panels. For the Shuttle safety -- let's stop here and explain that. The Shuttle safety, we used what we called concurrent engineering, which means that safety considerations that are incorporated into the designs are part of the design process, so it's just like another working group if you like. Same thing you do on airplanes, same thing we did on the previous spacecraft, Apollo and so forth. So for the Shuttle and the Orbiter we used concurrent engineering. What I mean is, more specific, the safety considerations that we created that I was just talking about that became design drivers for the Orbiter, to ensure that those were incorporated, why, we had a safety kind of a splinter group or something that would focus on that, and they were part of the team that was doing the design work. So it's concurrent engineering. Then of course those things were always addressed in reviews and so forth.

But then for the payload customer, we developed a different approach. For the payload customer we developed safety review panels. Why did we do that? Well, the reason was because when we're doing our own hardware and we have a large number of people, subsystem managers, so forth, we're on top of it, we know what's happening, we're involved, the civil servants are involved with the contractors and all working together. We know what's being done. In the case of a payload customer, he's off somewhere cross-country maybe in his garage or -- depending upon what kind of payload he has -- we've had some people like that, by the way, for small experiments -- you don't know exactly what they're doing. You're not following every step of their process. Their design process, their manufacturing process, their quality control, so on and so forth. So we set up as an adjunct these payload safety review process and payload safety panels. That's why we did all that.

The other thing that we did that's a little bit different is that since we didn't know so much of what they were doing, we added a little margin in our requirements for them for safety. What do I mean by that? What I mean is for example like on Apollo since we were so weight-constricted and so forth we were mostly what I call single-string, which means we were zero-fault-tolerant. Wherever we possibly could we went at least two strings. So it was single-fault-tolerant, which means that if something doesn't work you got a backup, redundancy. Where you couldn't do that at all we relied upon high reliability in the components and so forth, a lot of .999 reliability that we would establish through exhaustive testing and life testing and performance testing and so forth.

On the Orbiter, on the Shuttle system, mostly we stuck to two-string-minimum single-fault-tolerant. Some cases we went higher than that on some of the controlling computers and so forth, the G&N [Guidance and Navigation]. For the payload customer we decided we wanted a little bit more margin. So we went with two-fault-tolerant, which means that for safety-critical functioning they would have three strings, and that would give us more margin in case something went phooey with their payload. I'll talk more about that a little bit later, but that's an introduction to the reason why we created a separate approach for the customers with the safety review panels and put a little more margin into it.

Why did we need more than one string? What are we talking about? Usually when you're talking about something that's a must-work function you will design it such that the strings to do it -- and usually this is avionics we're talking about, but strings to do it will be multiple strings in parallel, and what that means is that if one string something doesn't work, why, then you've got a separate string side by side that will work and so forth, and you can have one, two, or three strings. If it's a must-not-work function, like you don't want a pyro to fire when it's not supposed to and so forth, now you're talking about series function. In other words, you want inhibits. You want one inhibit in one string. Okay, maybe you want two inhibits in the one string, maybe three inhibits in the one string, so you guarantee that it won't function when it's not supposed to. So you'll see, we'll talk about that maybe a little bit more later. But that's the general approach.

The safety reviews that we set up, we set up a system where we had for the customer phase zero, one, two and three. What in the world is that? Phase zero was set up to be a preliminary review, usually almost informal. Be sure that the customer understood the requirements, and oh by the way the onus was always on the customer to prove that his payload met the requirements for safety. We didn't have to do that. We expected the customer to do that job and then come tell us why they thought their payload was safe enough to fly. Then we had a phase one that was a little bit after the customer's PDR, which is a preliminary design review. Then a phase two after the CDR, their critical design review, and then finally a phase three with all the final results showing and demonstrating that everything they've incorporated into their designs is actually functioning and working. That would be after all their tests and so forth.

ROSS-NAZZAL: Did you ever have any payload that failed any of these reviews?

WREN: Oh yes. (Laughter) Yes actually we tried to be very helpful when we did that because we wanted the customer to succeed in addition to being safe. So even though it was set up so that all we were supposed to be concerned about was safety of the Orbiter and the Orbiter crew, we went out of our way to be sure that we helped as much as we could the customer so he or she would have mission success as well. We created some interpretation documents for some of the requirements to help them understand what our thinking was. It's kind of the same way we do the flight procedures that we use in mission control where you've got a whole list of steps and procedures and then you've got another list of things over here on the side that explains why, what's behind each one of those steps. Well, we did the same thing to help the payload customer with some documents that would try to explain the rationale and reasoning behind the requirement that we had established. So yes we did quite a few things to try to help them.

To get to your question then, they would come in sometimes, say with a design that we could see right away was -- either through our experience wasn't going to function the way they hoped it would, wouldn’t work, or maybe there's two or three approaches, they've taken one approach, that's fine, that's up to them, but on the other hand people here's a couple other things that might work for you sort of thing. In some cases we would find somewhere uh uh, no, that won't work at all. Or perhaps they had misread, and understandably perhaps, what it was that the Orbiter had to offer in the way of a service that could be incorporated into the functionality of them ensuring mission success or safety. For example maybe they needed two strings, and they were depending upon one string from the Orbiter services that were being provided, but they misused that somehow. We would catch those kinds of things. Sometimes they were just way off base with their whole approach in their design. Usually, as one would expect, the larger contractors that were doing the payload understood and had enough experience that they were pretty much on target. We didn't find a whole lot of things there. But it was the small customers and experimenters, oftentimes they just didn't have the experience base to work with. So we would find things there that they just missed and didn't do quite right.

One of the things that's really important in this process is the end function. I can't emphasize this enough to the young folks coming along. When you design some hardware to go do something in space, keep in mind that end function. Because we found, for example, that you can quality check the design drawings, and hey they're okay, and everything is fine, except that nobody bothered to go ahead and check the end function. So they built their hardware and so forth and then go to use it and say they hadn't checked it and they go to use it on orbit and ooh bad things happen.

I can give you one example of that, would be the Superzip. Superzip is a pyro charge that separates a connection. Like you go around a stage. Say you have an upper stage that you're carrying up in the Orbiter payload bay and you have it mounted in there and the way you eject it is you have some springs to lift the payload, upper stage, whatever it is, out of the bay. In order to release it there are several ways. You could have some clamps, some mechanisms. Or you could have a piece of structure that goes around there and it's got a charge in it, a pyro charge. What you do is you fire the pyro charge, and that splinters the structural connection and then allows springs to push the whole business out.

In the case of Superzip -- that was just a brand name for one of these shaped charges that went around a structural piece like that. On orbit we had one of those -- well, it spread pieces of the structure when it fired all over the payload bay. Fortunately it didn't cause any harm. But it could have. So we went back and discovered that what happened was that they built the Superzip and the structure and all that and the circuitry to fire the pyros exactly to print. Everything was fine. They did that.

But they didn't check the end function. Well, in checking the end function one finds that one of the designers that designed the circuitry to fire the pyros had had two pyros in there. So the idea was that one would fire and then the second one if the first one didn't go, the second one would fire a few milliseconds later to guarantee a separation, because you don't want a hang-up. Well, this designer, he saw it or the technician that wired it up, said "Oh, well there's two charges, okay, two is better than one." So he wired it such that they would both fire at the same time. Well, what happened? That was too much of an explosion and so it was overpowered and instead of just getting a little separation, a break, why, parts went flying everywhere.

So my point, there's a case of check the end function, what is it you wanted it to do, and be sure that you get what you thought you were going to get. So that's another reason why testing is important. I'm very big on testing. I know that people have asked me in the new program to go back to the Moon and on to Mars and these new programs should we test or not test. Well, I'm sorry, folks, I'm always on the side of testing, because I don't care how well your design is and your calculations and analysis and all that and even your component tests and your subassembly tests. You best do a full systems test. Test, test, test. Yes, it will be more costly and it's going to hurt your budget a little bit, but it's better in the long run.

So I'm a firm believer in lots of testing, and as a matter of fact the Marshall [Space Flight Center, Huntsville, Alabama] folks, [Wernher] von Braun's team, boy, they really believed in testing. They tested everything. They overdesigned a lot of parts and made it real beefy and then they tested it too. We also found when we started working with the Russians -- they didn't have the computer capability that we have; they did a lot of testing. A little shy in some cases on some of the analysis, but they tested like crazy. So I think testing is very important.

When we did all this payload integration process work, of course we had control boards to control the process and control the configuration, configuration control boards. The PSRP [Payload Safety Review Panel] we set up, payload safety panel, was set up to be chaired by the Program Office. Then supported again by Engineering and Ops and the Crew and Life Sciences and so on. The very first panel that we set up, I think the first chairman -- Leonard wasn't the chairman. A lot of folks thought Leonard Nicholson was but I don't think so. Skip Larsen and I went through that a few years ago and tried to track all that, and I don't have that paperwork handy, but as best I remember, Harold [E.] Gartrell was the first chairman and then Cliff [Clifford E.] Charlesworth followed him [and maybe Larry Williams] and then Dick [Richard A.] Colonna, Bob [Robert L.] Blount, Harold [F.] Battaglia and Skip Larsen [backed by David E. “Dave” O’Brien and Jeff Williams]. Then for the Engineering support to that, the first one was Don [Donald G.] Wiseman as I recall, Larry [E.] Bell, Helmut Kuehnel, and then yours truly for quite a while. It was supposed to be a one-year assignment and I think I ended up doing that for quite a few years. But in any event.

So we also of course worked with the DOD [Department of Defense] quite a bit. I'm not going to go into any of that. We worked with international partners and so forth. We accommodated that. So that's how I got into and how we started the integration process with the payload safety panel as an adjunct to that. Of course a lot of the payload interface wasn't to necessarily safety, it was just accommodations and everything would work together. That's why we had the cargo integration reviews and so forth. On the Shuttle, by the way, we had like I said concurrent engineering there, so we handled that in a little bit different fashion. We had an integration review that we created just to be sure -- Dave [David W.] Whittle headed that up out of Skip's office and I supported that -- that would be sure that the external tank and the SRBs [Solid Rocket Boosters] and the Orbiter and everything would play together.

ROSS-NAZZAL: One thing I was curious about when I was reading through your biographical information yesterday was how did you come up with these requirements when the design of the Orbiter was not completely set at that point. How did you come up with some of these requirements? You did mention that they were also design drivers for the Orbiter. So how did you balance the two?

WREN: Well, essentially we started I guess again with the functionality, what it was that was required in order to give a service to the payloads. First of all we're going to give them a ride to orbit. Second of all we're going to provide them with power that they need [to] keep alive while they're in the payload bay and for different functionings and so forth. We're going to provide them with certain environmental conditions: thermal, heat, cold, so forth. So we had to establish what that would be, what the payload would require. For example we have a 15-foot-by-60-foot payload bay, but we knew that we couldn't give all of that to the payload customer, so we had to have a little margin, because why?

Well, for one thing is that if you instead of ejecting with springs like I was talking about earlier, let's suppose that you used another way to get the payload out of the bay, which is use the RMS, or remote manipulator system. Then it's got a little tolerance on how finely you can control something that's attached at the end of the arm, the Canadian arm. So we allowed a little bit of -- essentially as I recall we gave them 14-foot instead of 15-foot for example. So you needed that consideration. You also needed some clearance. As the Orbiter moved and deflected and vibrated and so forth you needed some clearance there. So we put in some pad so that what the customer would end up with was less than the 15 and of course less than the 60, same thing there on the length.

Then we had to have supports for them. Structural supports, approach, and whether it would be statically determinate, indeterminate, all those kinds of things. What kind of attachments. If it was a large payload and the whole thing was going to go out, then we would have latches that would unlatch. We designed all those for them and then described to the customer what we had. But we kind of guessed, I guess, at a lot of the customer requirements, and what they would probably need. See, at the same time -- and this is another thing, is that we were doing a lot of in-house studies on some of the payloads. I'll get into that in a little bit perhaps, in a little bit. The upper stages and so forth. So we kind of had a feel for what the payloads would probably need in a lot of those cases. So then we used that as design drivers like I said for the Orbiter.

ROSS-NAZZAL: So you were doing in-house studies. Did you also award some study contracts to outside contractors as well?

WREN: Yes in some cases. As kind of a sidebar adjunct, we did some potential trade studies on payloads. The Program Office had set this activity up and I supported that. Hugh [Hubert P.] Davis and Ralph Hodge (phonetic) and some other guys [like Richard B. Davidson, etc.]. These were parametric studies that we did on -- upper stages was one example. We went through what designs would work best to be accommodated in the Orbiter in order to accomplish the job. Like an upper stage that was going to take something from low Earth orbit up to geosync [geosynchronous] orbit, should you use solid propulsion, liquid propulsion, single-stage, multiple-stage or what? We went through a lot of studies like that. We had on-orbit tugs, orbit-to-orbit, in those kinds of studies, the parameters were the usual, performance, throw-weight, specific impulse, whether or not it was throttlable, stop, start, reusable, and of course the different kinds of propellants: Earth-storable, cryogenic, monos, bi props, and what kind of pressurants. So in the process of going through those things, and the must-work and must-not-work functions, parallel inhibits, series inhibits, power trains separate from control trains and the logic and all that, and also safe distances to lifting inhibits before firing, so it would be safe for the Orbiter and the crew, and all those things led to an understanding of what the payloads might require so we could put that into the design drivers as well as accommodation documents, and be sure that they had those services as well as what was designed to be available by the Orbiter.

ROSS-NAZZAL: At that time you were anticipating working with DOD. Were you also anticipating working with international partners?

WREN: Yes.

ROSS-NAZZAL: How closely were you working with DOD and the Europeans, for instance, who were working on Spacelab at that point?

WREN: We were working very closely with the Europeans. I'll talk first about Spacelab. The Spacelab effort was as I recall was out of Marshall. I can't recall all the fellows' names now, or all the people's names [but Bob Crumbley and others worked with us]. But we worked with ESA, European Space Agency, on the design of the Spacelab. [Alan Thirkettle and many, many others, worked with us.] The Spacelab at that time, it was kind of considered to be part of the NASA elements, as against a payload, outside payload element. We had decided, somebody had decided, that we needed to have a lab that we would put in the bay, and it would be kind of like an element of the Shuttle system. So we worked very closely with Marshall to create that. Then they hired and engaged ESA to actually build it, fine detail design and manufacture it. So it was a little bit different than the people coming in through the front door with the payload hats on. It was more like a Shuttle element.

Why is that important? Because some of those margins and so forth I was talking about earlier were relaxed a little bit because we knew what they were doing. Marshall was involved in it. It was almost concurrent engineering in a lot of cases there. We knew what ESA and their contractors were doing. But yes we did work quite extensively with them. I can remember one example in the structures area. I think this is right. That we allowed a factor of safety of 2.0 no test instead of 1.4 and testing, because we and Marshall knew what they were going to do and followed it very closely. So we allowed that to happen. Then that kind of set a precedent which we later adopted for the payload customers that if they did testing on their actual flight article then we would allow them to use -- well, if they used a factor of safety of 2.0 then they would not have to test their final article is the way it went. Where with the 1.4 we had testing.

[Many of our structures people participated in these activities including, as I can recall, Ben W. Holder, Philip C. “Phil” Glynn, Alden C. Mackey, George A. Zupp, Herbert C. “Herb” Kavanaugh, William W. “Bill” Renegar, Orvis E. Pigg, George W. Sandars, Harold H. Doiron, C. Thomas “Tom” Modlin, Thomas L. “Tom” Moser, and others: Billy V. Zuber, Frederick J. “Fred” Stebbins, David A. “Dave” Hamilton, Stanley P. “Stan” Weiss, William F. Bill Rogers, and Kornel Nagy.] Similar things in avionics controls and so forth. So that's the way the Spacelab was handled, more like a Shuttle element if you like.

As far as the DOD goes, I would say that we worked with the DOD and they had certain requirements. Early on they wanted to either have their own Orbiter, own Shuttle if you like, or separate programs. It's kind of like back in the Station studies. I don't know if we mentioned this previously but they had their own Station plans, a DOD Station. They had crews set up for that, astronauts, that were for the Manned Orbiting Laboratory, I think was the name of it. That finally was done away with and they were encouraged to make use of the one Shuttle system. They were encouraged earlier if we did a Station to just use one Station, and we'd build several and then hey, the DOD, if they needed to use one in a different orbit -- we had Stations going lots of different orbits. We had polar orbits out of Vandenberg [Air Force Base, California] and we had all kinds of things. So we said, “Hey DOD guys, if you want to use one, why, we'll build another one and then you just go use it.” So the crews that they had appointed to those positions came over to the Shuttle, to the NASA side. I don't remember all the names, but they were probably five, ten, fifteen of them at least that came over, that originally were DOD [astronaut] teams on the Manned Orbiting Laboratory. So anyway ended up then that the Shuttle system was used for some DOD purposes. I can't talk anything more about that.

ROSS-NAZZAL: Right, you had a top security clearance.

WREN: Right. I was involved in that and that's about all I can say. They were all successful.

ROSS-NAZZAL: Could you talk to us about some of the challenges that you faced though working with some of those DOD payloads compared with the commercial side of things?

WREN: Well, I don't know what I can say and what I can't say. Suffice it to say that a similar parallel system was set up for assurance of accommodation and safety. I was involved in that. So we were happy and had confidence that if it was a DOD flight there would be safety of crew and Orbiter as well as mission success for whatever it was. When you worked with the DOD, they had a longstanding hired contractor called Aerospace that they utilized as an aid and a support for whatever it was, whatever DOD program they were involved in. So oftentimes we would say like do an analysis of something and then the DOD would have Aerospace do exactly the same analysis, and then they'd be compared to see if they were close. They always were close and matched. After a while I think maybe that powered down a little bit, didn't do so much of that, because it was showing that the analysis that we were doing or we were having Rockwell do or whatever was fine. But no, we had no problems working with the DOD whatsoever.

By the way, I will say this. That when we did our cargo integration reviews for the Orbiter that I was talking about, and all the different reviews we had, and FRRs and so forth, and the integration process, when there were designees that would assure us that certain things had been done right, and so all we would see if you were an Orbiter person, you would see there was an envelope there, an empty space envelope in the bay for example. You didn't need to know what was inside that. So that's the way we handled that.

ROSS-NAZZAL: Before the Space Shuttle ever took off, what were some of the biggest concerns that you faced while working payload issues? Really in the '70s before the Space Shuttle was operational.

WREN: Well, to be sure that the customers would be understanding what the Shuttle, the Orbiter, had to offer, and what its limitations were, what it had to offer and what it didn't have to offer, so that they could design their Tinkertoy accordingly, and it would have the right stuff if you like and be compatible. Then to be sure that what they incorporated into their design did meet all those requirements. I guess that's probably what we did.

ROSS-NAZZAL: Were you working with the -- what are they called? The Space Shuttle student experiments at that point? Or did those come later?

WREN: I don't remember the timing on that. They came pretty early. I had almost forgotten. That's a good point. There was a program to accommodate students with their experiments. Early on it was called the Get Away Special Program and what we did is we created some what we called gas cans that were mounted out in the bay on the sidewalls. They were beefy enough so that then a student's experiment could go inside the beefy canister and if something went phooey with it, why, it wouldn't be a danger to the Orbiter. So we had some protection there both structurally and then of course with the avionics and so forth. Early on those were closed canisters. Later on we developed some where the lids would open, so in case the experimenter wanted to look out at the stars or look at something, it had capability for visual path for their experiment.

As a matter of fact, I remember our Space Center Rotary Club, which has a lot of space people and NASA people in it, we set aside I think it was $10,000. I can't recall the name. There was a teacher over at Clear Lake High School [Houston, Texas] that was going to have his students create an experiment to fly in a gas can. We set aside the seed money for them to do that job. There was a certain amount of dollars that needed to be put up to reserve a space in a gas can. I don't remember, $500, $1,000, something. We held that money a long time, and the problem was that the teacher over there, it took a long time to design it and manufacture it and so forth, and his students kept -- freshmen and sophomores, junior, senior and then they'd leave. (Laughter) So he kept having a turnover in the people working on the student experiment, and never did get one that was ready to fly. So I think we finally said, "Okay well we'll put the $10,000 to some other use," scholarships or something. But yes that was the Get Away Special Program. That's right. I'd forgotten that.

ROSS-NAZZAL: That's interesting. Well, before we talk about the flights of the Space Shuttle and the work that you were doing there I thought we'd turn our attention to the Shuttle Carrier Aircraft [SCA], which was another position that you were working on.

WREN: That was another thing that came along, right.

ROSS-NAZZAL: How did that opportunity come about?

WREN: Well I guess I was pegged. That team was set up -- John [B.] Lee again -- I can't say enough good things about John. He worked in Max's [Maxime A. Faget] Engineering Directorate office. John, by the way, just got an award from Virginia Tech [Blacksburg, Virginia] here a few weeks ago. John flew P-51s in World War II, and he was part of the original Space Task Group. He's still in our Rotary Club so I see him every Monday. But John was Max's leader for this engineering support for the Station and Base studies. I was in charge at that time of the structures aspects for all those studies. Then John also when this Shuttle Carrier Aircraft program came along, he was in charge of that for the Engineering Directorate, and then again I was in charge of structures for the directorate for that effort.

What the task was is primarily to create a capability in case the Orbiter landed on the west coast or at White Sands [Missile Range, New Mexico] instead of at the Cape, [Canaveral, Florida] to get it back home to the Cape. So we needed some way to carry it other than on a barge or whatever. Of course it wouldn't fit in a the Super Guppy so we needed some way to do that. So somebody came up and I don't remember who, but somebody came up with the idea well piggyback it on a big airplane and carry it.

So when I got involved in it, why, we were still looking at what airplane would we put the Orbiter on top of. Had to decide that first. We looked at the C-5A, Lockheed airplane that the military used. It had some advantages. Then we looked at the 747 that Boeing had, and it had advantages. As I recall some of the primary advantages in C-5A was that it had a deck on the bottom, extremely strong, to carry tanks and so forth. So in order to put an Orbiter on top all we would have to do from a structural aspect would be to run some struts right straight down to that floor, and that would be the end of it. That would be real easy because the floor was so strong. Some of the negatives though were that it was very very low to the ground, and clearance was real low.

On the 747, what we would have to do -- and we did, and it really didn't turn out to be that big a problem. Since there was no strong floor at the bottom what we did is we sheared the load from the Orbiter and the tie trusses then into the fuselage panels, fuselage body. We called it sheared in, to spread the load out by stiffening up the body of the 747. Some of the advantages of the 747 was it was higher off the ground and gave us a little more leeway and clearance and so forth. There were also some advantages from a handling and performance point of view that were realized through extensive wind tunnel testing. But in any event, why, the 747 was chosen.

The 747, when they designed and manufactured it, they created a whole different facility up there instead of in Seattle [Washington] or Wichita [Kansas]. They had a whole different facility for that. They did B-52s at Wichita and commercial airplanes mostly in Seattle, downtown Seattle. The space group was out at Renton [Washington] but they created this whole new facility up at Everett north of Seattle and it was devoted to 747s. So we went up, our NASA team went up to start working with the team that was set up, a special team out of the 747 group, at Everett. As a matter of fact they brought -- and I pointed this out in the notes -- they brought their top people to support this program because it was so important to them to be sure -- for NASA to carry the Orbiter it had to be done right. So they got the cream of the crop. First of all, it was a pleasure to work with the commercial airplane group, because there’s some sharp people in Boeing in the commercial airplane group -- 707s, 737s, all that, and especially the 747. They thought it was so important that they brought their chief of design for the 747 out of retirement, Vern Hudson, to work with us. Boy, he always had a twinkle in his eye and a smile on his face, but sharp as a tack, and was fun to work with.

It's always a pleasure through your career when you run into folks like that. It's like Ken Eldred I talked about with Wyle. They also had a head of Structures, and he wasn't quite retired yet, was about to retire, Jim Fuller. So we got to work with Vern Hudson and Jim Fuller and that made life a whole lot easier, because they knew what they were doing, really crackerjack. Some of the things that we did, the enhancements to the 747, and like I said the truss, we sheared the loads into the fuselage so we beefed up the fuselage. We added vertical tail fins onto the 747 for added directional stability. Of course the indications for that came out of the wind tunnel testing. Then of course we had a Shuttle tail enclosure for aerodynamic reasons that we put on the aft end of the Orbiter for the transport activity. We of course had all our design reviews and everything through structures, aero, avionics, all that stuff, and had big teams for all those efforts, had those up at Everett.

Joe [Joseph S.] Algranti was right in the middle of that, and he was head of the flight group here at NASA, and he was the first one to fly the modified 747. I don't recall the names of the Boeing pilots. They were also involved, but Joe was the first NASA guy to fly. [Also involved was Arda J. Roy.] We did extensive testing naturally, as one would expect, on the aircraft after the modifications were made. Of course we had design reviews, the usual things, preliminary design reviews, critical design reviews, so on and so forth on the modifications.

In order to satisfy ourselves of the performance we had extensive ground runway tests where you powered up and go like gangbusters down the runway but you don't rotate and take off. Then we had flight tests, and we flew it without anything on it, without an Orbiter. Of course these things are always highly instrumented so you get all kinds of data back and so forth on the performance. Then we added the Orbiter on top and we went through the same thing, mated runway test and mated flight test without separation, just to get the handling characteristics and stability characteristics and so forth adjudged. In addition to utilizing the modified 747 for this transport from coast to coast we used it for the [Approach and] Landing Test [ALT] for the Orbiter. So it had a second usage, which was very important, was to take an Orbiter up and separate, and then have the Orbiter come down for its checkouts on performance and handling. So it was used as a tool to carry the Orbiter up for the landing test of the Orbiter.

ROSS-NAZZAL: Let me go back and ask you a couple of questions. One, how much time were you spending up in Everett at that time? Were you going up for the week and coming back on the weekends? Or was this just something you went up there once a month?

WREN: It varied. I think we had all of our reviews up there. Some reviews would be a few days, some maybe a week or two. But we were always going up as the program progressed for splinter groups if you like. Different technical groups would go up for meetings with the counterparts in the Boeing group and go over problems and issues and always problems to be solved, and what the status was, where we were, so on and so forth. So yes, sometimes you'd spend a couple, three weeks up there at Everett and sometimes you'd just be up there for a review, which would be a few days to occasionally a week I guess.

ROSS-NAZZAL: You mentioned that there were always problems. Do you recall what some of the larger problems were that you faced?

WREN: No. (Laughter) Actually we didn't have very many big problems. I want to say that right away because of what I said about the crack people and all the good work that they did and analysis and so forth. But no matter how good you are you always have some problems, and I don't remember, they're all of a minor nature, so I don't remember now what we had.

ROSS-NAZZAL: You mentioned wind tunnel testing. Was that done at Boeing or was that done at NASA facilities?

WREN: I don't remember but I would suspect that depending upon the size of the models, and certainly the larger models you've got to have larger wind tunnels, that there's wind tunnels of course at several NASA facilities, at Ames [Research Center, Moffett Field, California] and at Langley [Research Center, Hampton, Virginia]. There's some wind tunnels at [Arnold Engineering Development Center] Tullahoma [Tennessee], believe there's some at Wright-Pat [Wright-Patterson Air Force Base, Ohio]. Boeing has some also. I don't recall where all the wind tunnel tests were done. Of course we had an aerodynamics team [which included Bruce G. Jackson, David Kanipe, Bass Redd, and Barney B. Roberts, etc.] that did all that sort of thing, and I don't remember where they were tested.

ROSS-NAZZAL: You had also mentioned the testing that was done on the SCA. Was that done in the Seattle area or was that done at Edwards [Air Force Base, California]?

WREN: Edwards. No, we did that at Edwards because why? Well, because Edwards is flat and it's large and so it has a lot of room for error and a lot of accommodation. If you want to land and the -- I don't know, three-mile, 15,000-foot runway is not enough, that's okay, you just keep on going. So it has a lot of latitude and flexibility there so it's a good place to do that sort of thing. That's why Edwards is located there as a test site. So plus the weather is great, as far as inclement weather and rain and that sort of thing. So no, Edwards was where we did all that.

ROSS-NAZZAL: You were there for all of the testing?

WREN: No, as a matter of fact I was not. I was off on one of these other things. So I did not go to the actual [Approach] and Landing Tests. I didn't go to any of them. I was aware of what was happening and getting the data from them, but I didn't actually go witness any of them. Kind of would have liked to, but I had other [assignments]. I couldn't do it.

ROSS-NAZZAL: You had on about three different hats at that point. So can imagine you were a little busy. What was it like going back to the environment of an airplane company then?

WREN: Oh I loved it. I'm glad you mentioned it, yes, because like I said before I started out kind of on the flight line in General Dynamics and Convair with the B-58 and the TFX/F-111 kind of thing, and oh I just love being around airplanes. Yes, so that brought back a lot of memories. Now I liked working with airplane people if you like. So that was fun. That was fun.

ROSS-NAZZAL: I can imagine it was.

WREN: Yes, and of course I knew a lot about what it took to build an airplane and how airplanes perform and function and so forth. So that was very helpful in addition to fun and enjoyable.

ROSS-NAZZAL: You were still working all the payload issues at this point.

WREN: Right. That's why I couldn't get to the ALT tests at Edwards.

ROSS-NAZZAL: The Space Shuttle was supposed to launch I think originally in '78, but the dates kept getting pushed [back].

WREN: Yes, and I don't remember when we actually first launched. Was it '81?

ROSS-NAZZAL: Eighty-one, yes. How did those dates impact the work that you were doing at that point?

WREN: It didn't really impact. We were kind of going down a parallel path, and we were like I said before in working with accommodations in payload integration, we fed that back in as quickly as we could so that they would still be meaningful as design drivers for the Orbiter. But the drifting of the Orbiter launch date probably helped us a little bit I suppose. Gave a little bit more time.

ROSS-NAZZAL: One of the things we didn't talk about, and I was wondering if you were involved in this at all, were you involved in the pricing of payloads, what it cost to actually fly, and working with that side of the house?

WREN: No, only on the periphery. I can remember the talk was that it was going to cost -- let's see if I can get these numbers right. Think it was $100 per pound to orbit, yes. So that a 200-pound person or payload then would cost $20,000.

ROSS-NAZZAL: That's cheap.

WREN: Yes. Well it turned out that that was pie in the sky. Didn't turn out that way. But that was the hope in the original design of the Shuttle system and the truck concept and reusable, that it would be a low-cost way of getting payloads to orbit. I think that's the right number, God I hope that's right, $100 per pound. I don't know what the figure ended up being, but it was nowhere close to that, it was much much more. One of the things that's important to point out probably about the whole Shuttle approach, unlike the 747 and those commercial airplanes and so forth, you do a 747 and you get it to a certain point where it's all checked out and now you're selling hundreds of them to different customers and so forth, and so they're usable airplanes. They're production craft.

The Shuttle system never got to that, and it really wasn't intended to get to that. It's so complicated and so detailed that the only way you could ever classify it is as an experimental vehicle. So it's not a production vehicle. Now what does that mean? If it's an experimental vehicle, that means that it's labor-intensive for one thing. You got to have a lot more people involved in supporting it, instead of a quick ground turnaround crew when you go fly Southwest and you get on a 737 and the crew comes out and changes the food or the peanuts, and takes care of the luggage and refuels and a couple of checks and away you go.

Well, you don't do the Shuttle system that way. In between every flight not only is it refurbished, taken apart and checked and so on and so forth, we have a design, kind of a review, a flight readiness review for each and every flight. Well you don't have that when you fly a 737 from here to Miami [Florida] or something. You just go get on. You don't have a review for every one, because it's a production aircraft. So we're experimental vehicle, so we have reviews for every time we do something. If there's an anomaly on a Shuttle mission then that's investigated; it's core-drilled and investigated very carefully, because the crew's lives are at stake, and so we just do that. All this takes people.

So it's expensive, and then of course there's the reporting processes and so forth and so on. If there's any changes to be made of course configuration control is always in existence, process control. Of course you have those things in commercial aircraft too, but you kind of do it and then you kind of set it aside and if something needs to be changed, like a luggage door or something, why, you generate an EO, engineering order, and you change the drawing, go out and fix it. Then that's it; you have inspections and so forth from time to time, quality control and that sort of thing. But you don't have to review it every time you fly. With our experimental aircraft we do. So that's why the cost is nowhere close to $100 per pound, if that's the right number, to orbit and back.

So there's advantages to that system, but there's expenses with that. Lower-cost ways to go to low Earth orbit and back is certainly a goal to be achieved, and that's why I was saying earlier that I was very interested and excited about what Burt [Elbert Leander] Rutan was doing with a different approach to take. I've often thought oh he's using the shuttlecock approach to get back down for example his vehicle, and of course he didn't go all the way to orbit, but that's a different approach, so he just backs down and comes straight down vertically, and then like a badminton shuttlecock, it just like that, as against flying it.

Another thing that I was always in favor of was using wings and aerodynamic lift as much as possible instead of just using brute force off the pad with a rocket propulsion. There were some efforts along that line earlier on with the B-52s where they carried upper stages. I think it was the Bomarc missile, I can't recall exactly, but it flew the upper stage up to altitude, and then released it, and then the upper stage went ahead and flew off and did its thing. It's like what Burt Rutan is trying to do with his carrier aircraft and carry an orbital vehicle or upper vehicle up using wings for lift in the early part of the launch if you like. Of course some people are toying with space elevators too. But there's other approaches. But anyway the Shuttle approach with all its complexity and with launching vertically and so forth, it's labor-intensive.

Of course the Saturn Vs that we used, very labor-intensive also, lots of parts. So it's a wonderful thing to watch take off, this 36-story building lift off the pad and rumble and boy it went slow, you're holding your breath because it took I think -- what was it? Seven or eight seconds of building up thrust before the umbilicals were released. They all had to be released within plus or minus so many milliseconds, so you wouldn't get a canting load on the stack. Then once it was released and started to move you're thinking oh my God how long is it going to take for that thing to get off the ground. Of course the Shuttle, it goes up faster. So it clears the pad much quicker.

ROSS-NAZZAL: I just thought of another question since we're talking about pricing and the low cost that was anticipated. Originally there were visions of launching 50, 60 times a year. What impact did that have on the payload schedule? How did you anticipate working with so many payloads and getting them through and putting them on board the Orbiter?

WREN: Well, yes, I guess, Jennifer, the original thought was to be launching Shuttles, I don't know if it was weekly, but certainly monthly. The payload schedule I guess would be rather heavy. But it wasn't long before it was apparent that we weren't going to be launching the Shuttle that frequently. So it never really came to be a problem with the payload accommodation process. So it really was not a problem.

ROSS-NAZZAL: Did you have any responsibilities for the first Space Shuttle mission, for STS-1?

WREN: No, not directly, no.

ROSS-NAZZAL: Where were you when STS-1 finally lifted off the pad?

WREN: Gosh, I don't remember. (Laughter) I really don't. I don't remember where I was.

ROSS-NAZZAL: Do you remember where you were when it landed?

WREN: No, don't remember that either. That's part of going with the territory I guess. I don't remember. I don't remember. And the only reason I remember the Apollo 11 Saturn V launch is because like I said we raced down there in our private hired airplane, rented airplane, to be sure we could watch it, because we couldn't get a commercial flight. So I remember that one. But no, I don't remember the first Shuttle launch.

ROSS-NAZZAL: What was the first STS mission that you helped support in terms of payload? Do you recall?

WREN: It was probably that first flight. I'm having trouble remembering, but I think we probably had a dummy payload in that first flight. By dummy payload, probably just a big old something that would span the bay and be attached to the supports on the sidewalls and had some mass and a proper center of gravity location, and it was just structure and had no avionics, maybe some measurements, accelerometers and that sort of thing, but it wasn't a functioning something, it was just a dud sitting in there, and I think we had that on that first flight, and if we did, why, of course I was involved in that, but I don't remember. But yes that would have gone through our process.

ROSS-NAZZAL: I'm wondering if you could walk us through the process of scheduling a payload and sort of mixing and matching payloads for missions and how that all worked.

WREN: That's right, that's a good point. The system was set up to have, as I mentioned earlier, payload integration managers in the Program Office. The responsibility of a payload integration manager, we had quite a few of the PIMs,* and they were assigned to a specific mission. It was their responsibility to orchestrate the mix of payloads that would be on that particular mission. So they had to coordinate not only with the various customers, say there was two or three payloads instead of just one, let's say, so that person had to coordinate that, and then had to coordinate all that activity through our approval process, our cargo integration reviews and configuration control and so on and so forth. Then the workings between, from payload to payload, the spacing, the loadings, we ran for example as I recall structural analyses [coupled loads analyses] of each Shuttle configuration and with its content of various payloads. The smart people went off and ran analyses to be sure that no load limitations were violated.

The same thing was done with the avionics. We had one of the Orbiter computers set aside for payload usage. So you had to be sure that the various -- say it was two, three payloads, that those accommodations were used appropriately by the different payloads. Also say that in the event of an emergency that payload computer could be confiscated and used by the Orbiter for its own purposes. But those kinds of things needed to be orchestrated, the usage of whatever functions and services that that payload computer would supply to the payload customers. That was all orchestrated by the payload integration managers, the PIMs. Of course we in Engineering supported that, and of course Ops supported it, so on and so forth. But that kind of coordination had to take place.

* Some of the PIMs as I recall were David D. "Dave" Deatkine, Richard M. Swalin, Albert Y. "Al" Ong, Jerry S. Lowe, Jervy J. "J.J." Conwell, Bob Everline, Bill Jordan, John C. O'Loughlin, James L. "Jim" Smothermon, and many others.

ROSS-NAZZAL: I'm wondering if you can share with me a little bit more about the organization, where you were in the organization, how that was all structured with the PIMs and where you were, at what level. Could you describe that a little bit?

WREN: Yes, the PIMs were located in the Program Office. The Engineering would support the process and the panels as well as Ops, Life Sciences and Crew. In some cases there would be different technical disciplines in Engineering that would support in some of those cases -- for example I was located at the time in the Structures and Mechanics Division. So any disciplines that resided within that division then I was responsible for. Later on I moved, relocated to the Engineering Directorate office. Then I was responsible for the same thing but for all of the [directorate’s] technical disciplines, avionics and propulsion and so on and so forth. So that's kind of the way it was set up.

ROSS-NAZZAL: Did you ever have the opportunity to work in mission control when some of your payloads were up and being deployed?

WREN: The way that worked was that in a mission if there's what we call an anomaly, then a team is scrambled to go work the anomaly in a room adjacent to the control room. Yes, I've supported many of those. (Laughter) It's kind of a tiger team where you go over during the mission, day or night, whenever it is, doesn't matter, and in my case usually I would grab the real smart people from the Engineering Directorate, whether it was only in our Structures Division or later on throughout the directorate, to form the components of the tiger team for investigating the specific anomaly that had occurred. Those anomaly investigations usually were conducted by somebody in the Program Office or somebody in Mission Ops. I don't recall now who did that, but somebody did that. Then Engineering was one of the supporters of that.

ROSS-NAZZAL: Any particular missions that stand out in terms of anomalies that you recall? Or just too many to remember?

WREN: Too many. Well, the Superzip incident was one for example. But there were others and I just don't remember them. I don't recall.

ROSS-NAZZAL: Once the Space Shuttle was up and running and it was declared operational, did you make any sort of changes to the process that you had devised in the '70s?

WREN: Well, let me put it this way, and I'll be real frank here. We were kind of giving short shrift early on to the payloads, because we were overwhelmed with trying to make sure the Shuttle could operate, the Orbiter could operate. That the requirements we had inputted would all work. Later on when we got comfortable with that, then we started paying more attention to accommodating and trying to help the payload customers. So we started creating even more accommodation documents and interpretation documents to try to help them out and be more friendly for their benefit.

A lot of like the battery studies that we did that our battery experts had done on the latest technology of batteries, lithiums and so forth, some of them were high-performance but as sometimes usually goes, the higher performance, why, the more unforgiving perhaps they might be. You don't want a battery to blow up on you, like some of the laptops where the batteries blow up inside, and there's so many new technologies, I'll give batteries as one example, of battery technology, that they have to be thoroughly investigated in all aspects to be sure that they not only perform well but that they're safe. We got a crack team of battery people at NASA that are involved in that sort of thing. We shared a lot of that information with our payload customers. Not only what battery selections for example, but how to use them and control them and so forth. So yes we did a lot of that to try to help the customers.

ROSS-NAZZAL: I just had one other question before we close today. Did you have a chance to go out to the Cape and work payload issues? Or were you primarily just stationed here at JSC?

WREN: No, we went to the Cape quite a bit. A lot of the payloads -- very few of them are what we call ship and shoot, where the payload, whether it's on an expendable or on a reusable on the Shuttle, where it's all prepared and ready to go and checked out at the manufacturing plant, and then you ship it down there and you mount it and shoot it. Most of them don't work that way. Of course one of the advantages of that in the DOD world is that you have less possibilities of compromise, for ship and shoot. But most of the time for other payloads, nonmilitary payload, a lot of the checkout and integration activity and so forth is done at the Cape. All of the integration checkout with the payloads with the Orbiter are done at the Cape. So we had a lot of payload reviews and payload activities at the Cape that we participated in, either just from our integration activities, and also our safety activities.

ROSS-NAZZAL: I think this might be a good place for us to stop. I thought maybe next time we could pick up with your change in position in '84 when you started working with Space Station and move from there.

WREN: Okay.

ROSS-NAZZAL: So thanks for coming in today.

WREN: Okay, thank you very much. Appreciate it.

[End of interview]