NASA JOHNSON SPACE CENTER ORAL HISTORY PROJECT
EDITED ORAL HISTORY TRANSCRIPT

RICHARD W. NYGREN
INTERVIEWED BY REBECCA WRIGHT
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WRIGHT: Today is January 12th, 2006. This oral history is being conducted with Richard Nygren in Houston, Texas, for the NASA Johnson Space Center Oral History Project. The interviewer is Rebecca Wright, assisted by Sandra Johnson.

We thank you for coming in this morning and visiting with us for this project. I'd like to start today by asking you, how did you learn of the opportunity to come to work for NASA in 1966?

NYGREN: Well, it's kind of an interesting story, because the NASA part of it is minimal, but how I got there was interesting. As everyone knows, in '66 we were in the middle of the Vietnam War; everybody essentially was being drafted at that point in time. As I was getting closer to getting out of school, I thought, well, I didn't want to get drafted, so I actually went to the Air Force recruiter and applied for pilot training. They took me out to Norton Air Force Base [San Bernadino, California] and ran me through all of the physicals and testing to qualify to get into OCS [Officer Candidate School] and into Pilot Training School. As I got closer to graduating in June, I hadn't heard from the Air Force nor had I heard from the Selective Service [System]. So I started saying, "Well, jeez, I've got to find a job so I'll have one if I don't get drafted or get into the Air Force."

I started looking around for where I could interview, and I interviewed with a number of paper companies and with John Deere in Waterloo, Iowa. All of a sudden a NASA rep

[representative] showed up on campus and did thirty minute on-campus interviews, interviewing eight or ten different folks. I applied to interview. Within two weeks of when I interviewed, I had an offer from NASA, from JSC [Johnson Space Center, then named Manned Spaceflight Center (MSC)], to come down and work in the Flight Crew Support Division.

I thought, "This looks pretty good, but I'm going to sit on it until I hear from the Air Force." I got up to just before graduation in June, and I hadn't heard from anybody, so I accepted the job, and I reported to work at JSC on the sixteenth of July 1966. In August I got a letter from the Air Force that said I'd been accepted to OCS training and I was supposed to report to Lackland Air Force Base [San Antonio, Texas] in November. I thought, "Well, there's still a chance I'll get drafted, so I ought to check with NASA and find out whether I should take this offer from the Air Force or stick with NASA."

I went over and talked to them, and they said, "Well, you can certainly go to work for the Air Force, but you have to reimburse NASA for your moving expenses from California to Texas." Well, I had about $300 to my name, so that wasn't going to be an option. So I stayed with NASA and for the next two years NASA and the Selective Service were in a continuing battle as to whether I was going to be drafted or whether they were going to give me a deferment.

But that was an interesting story that started off with my local draft board in Nevada trying to draft me, and through NASA negotiation they had me go through the local board, the state board, the state technical board. Then they transferred me to Texas. I went through the local Texas board, the state board, and finally at the Texas technical board, I finally got an actual deferment and stayed at NASA. But, interestingly enough, it was never a long-term goal that I knew we were going to the Moon and I wanted to work for NASA or be an astronaut or anything

like that. It was a case of at the last minute I really needed to find a job, and NASA looked like they had the best one to fit what I wanted to do, so I joined them. [Laughs]

WRIGHT: Were you familiar with what NASA was doing at the time?

NYGREN: Oh yes, from the newspapers and the magazine articles, I knew what they were doing. But it really never came to me that that would be something I would do. Growing up in Nevada in a real small town, my dad had a honey business, and we ran that out of his grand dad's ranch, everything was jerry-rigged and bailing-wired together, and I guess I never thought I qualified for NASA. I was more building tractors. Interviewed with John Deere, and I interviewed with a couple of paper companies that built paper products and worked in the forestry business and grew their own timber. So I was more thinking outdoors, and I thought these rocket scientist guys were in a different category.

But when I interviewed with the NASA rep, he told me about some of the different aspects and everything, and then when they offered me the job, which was in the Flight Crew Operations Directorate, and "Deke" [Donald K.] Slayton ran that, but the job was in the Flight Crew Support Division under Warren [J.] North, and they did a lot of travel and testing of the spacecraft and interfaced with the crew and the contractors and the flight control team. It looked like an integration job that involved interfacing with a lot of people, and I thought, "Well, it really sounds like it would be a neat job to do." So I accepted it, I got into it, and I'd be hard pressed to say that I really didn't enjoy everything I did with NASA. I had the best jobs, the best bosses. I wouldn't go back and think about changing very much of it at all. It was a real good experience.

WRIGHT: Tell us about your first impressions of moving to Houston.

NYGREN: [Laughs] Well, I grew up in the desert, and I went to school in California, so moving to Houston in the summertime was a real experience. I really lucked out; there was a friend of mine that had graduated from Northrop Institute of Technology [Inglewood, California], which is where I went to school, a couple of quarters before I did, and he was working here. He offered to let me stay with him for a couple of weeks when I first moved here.

I didn't have a car. I had a little Honda motorcycle. It was a 90cc motorcycle, so you couldn't even go on the freeways. All you could do was just putter around from here to there. I got down here, and that summer, for whatever reason, it seemed like every afternoon at four o'clock a thunderstorm came. Driving around on a Honda motorcycle in a thunderstorm isn't any fun at all. I also found that there was a certain segment of the Texas population that felt that the most exciting thing that they could possibly do was drive alongside of a motorcycle and get them just as wet as they could possibly get them. In a very short period of time, when I had just enough money to make a down payment for a car, I bought a car.

But I guess I've never gotten really accustomed to the heat and humidity of Texas. I don't know how people can do that, but I have not gotten used to it. I enjoy the work, so if you enjoy the work, you put up with the climate that you live in. I lived right outside the gate for about the first year. Then, one of the guys that came to work one pay period before I did, a guy by the name of Ray [Renato D.] Dell'Osso, [Jr.], and a friend of his by the name of Mike [Michael M.] Thomas, who were both graduates from [the University of] Notre Dame [Indiana]—we moved off Belfort Street on I-45 [Interstate Highway 45]. We had an apartment

there for a couple of years, traveling back and forth and having a good time. Mike was in the Engineering Directorate, but Ray was in the same organization that I was. In fact, he still works out here. He's the Division Chief in the EVA [Extravehicular Activities] and Robotics Division in MOD [Mission Operations Directorate] organization.

It was really interesting, because when we were working, and Dell'Osso was with me, we were doing exactly the same kind of work. He was an electrical engineer from Notre Dame, and I was a mechanical engineer from Northrop. We'd look at the equipment and look at the drawings and the schematics, and Renato would be saying, "You know, I don't understand all of these drawings. I haven't dealt with those things before." Then we'd get into some electrical or software issue, and he knew how to program software. I didn't know about that.

I'm thinking, "How can both of us have engineering degrees and have such diverse backgrounds? I can weld and rivet and plaster cast and read drawings, and he can program software and run programs and do analysis." So it was interesting to start working with people who had come from different universities and different backgrounds and really see how diverse it was, but at the same time how well we worked together. You could draw on each other's strengths and get the job done a lot better when you were coordinating with each other.

WRIGHT: Tell us about those first job duties that you had. I understand that one of the first areas you were assigned to was to work with Frank [F.] Borman [II] and the Tiger Team. Did you have something before that happened?

NYGREN: When I first came on board, I got into Warren North's division. There was a guy by the name of Jim [James C.] Shows, who was the Branch Chief, and a guy by the name of Lou

[Louis D.] Allen, who was the Section Chief. I worked on what was called the flight crew support team. The team was comprised of a team lead, a crew station engineer, and a crew equipment engineer assigned to each one of the missions, leapfrogging forward four or five missions, so there were four or five teams. I was assigned to be a crew equipment engineer on both the Command Module and the Lunar Module [LM], and my first assignment was on spacecraft 103 and LM-3, and it turned out to be Apollo 9.

So I worked on that team. Jim [James L.] Lewis was the team lead. Dave [Lynn D.] McBride was the crew station engineer for the Command Module, and Marion [W.] Hix was the crew station engineer for the Lunar Module, and I did the crew equipment work. The team was responsible for doing a lot of the interface for the astronauts at the factory. When I first came on board, I was assigned to LM-3 and spacecraft 103 as they were going through some of their factory checkout in Downey [California, North American Rockwell Corporation].

On one of my first trips to Downey, we were doing what's called a crew compartment fit and function, a C^2F^2 [*c* squared *f* squared] test, which is where the crew goes into the spacecraft and exercises all of the loose equipment. We stow the loose equipment like it's supposed to be installed for the launch environment, and then we have the crew take it out and install it where it will be used during the mission. This way we can identify if we have a camera hanging in the area where somebody needs to open a locker, or we have a suit in the way of opening a hatch. We go through and make sure everything fits the way it's supposed to fit.

Back in those days there wasn't much of this off-the-shelf business. Everything was custom built for its unique purpose; we had to check everything to make sure that it fit. It wasn't like going out and buying a set of screws. You know that they're all going to be threaded just

perfectly. It was more a case of every handrail was custom built, so every bracket that had to go to that handrail had to be adjusted and aligned to it.

I was out conducting the crew compartment fit and function when the Apollo 1 accident occurred, and the crew was out there. [James A.] McDivitt, [David R.] Scott, and [Russell L.] Schweickart were out in Downey at the same time. They were at the spacecraft, and we were doing some of the testing when one of the Rockwell guys came up and mentioned that there was some kind of a problem. He took the crew off to the side and told them about the fire. Then the crew left; they had some astronaut offices in the North American buildings. They were gone for, I don't know, thirty or forty minutes. Then, they came back and pulled me aside and essentially told me what had happened, and that they were not going to stay around for the tests. They were going to go back to the airport and get in their T-38s [Talon, jet trainer aircraft] and fly back to Houston. So I got involved and became aware of the fire at that point in time.

A couple of days after that we'd finished up what portions of the test we would be able to perform. We then put all the hardware back [on board] and I flew back to Houston. When I got back to Houston they had established the fire investigation team. I got assigned to work in the thermochemical test area, which is at JSC on the north side of the campus. They had set up a Command Module out there, and they were trying to reproduce the fire that happened at KSC [Kennedy Space Center, Florida].

They would configure the Command Module in a launch environment, and then they would go into the spacecraft and set off fires with specific ignition sources in specific areas, and this would create an artificial fire inside the spacecraft. We would go in afterwards and take all kinds of photo documentation of the interior of the Command Module. We would have photographic equipment looking through the windows so when the fire actually occurred, you

could see how it propagated throughout the spacecraft. Then we would take the video and still photos from our test, and we would compare it to what the Apollo 1 spacecraft actually looked like. What we were trying to do is recreate a similar burn environment so we could isolate where the actual fire started and maybe identify the source.

I was involved with this testing for several weeks, and I remember that it was one of those twenty-, twenty-two-hour-a-day, seven-day-a-week activities; and I got sick as a dog and was laid up for about a week. We eventually finished the testing, and by then they had started talking about forming the Borman Tiger Team that was going to go out to Downey and work with the North American guys in trying to redesign the spacecraft and come up with the Block Two configuration of the Command Module. I guess because of my familiarity with the crew station equipment, the layout of what the crew station needed to be and the mission scenarios, I was assigned to go out and work with the North American team in trying to lay out the actual spacecraft design for the interior.

From the fire we realized the hatch we had was the wrong hatch. The hatch came in as opposed to going out, so that when there was an increased pressure on the inside of the spacecraft, the crew couldn't remove the hatch. We needed to look at a hatch that would actually go out, but you also needed to be able to have a hatch that you could open when you were laying in the seats in a suit. You had to have a mechanism that would be accessible by the crew when they were lying in the seats.

When you land, the seats are going to stroke down. Whatever you put under the seats either has to be clear of the stroke envelope or crushable. We had to design our stowage that was going on the bulkhead so it would clear the seats and wouldn't interfere with the stroke of the

seats. Depending on what angle the Command Module actually hit the water the stroke envelope would be different, so we spent a fair amount of time working these types of layouts.

We had to worry about where the equipment was going to be stowed on orbit. When you get on orbit, you have to deal with suits. You've got to figure out how you're going to don and doff the suits. When you dock with the Lunar Module, you've got the probe, drogue and hatch that you're going to temporarily stow.

The job was understanding the environment, the equipment and how it was going to be used during the seven- or ten-day flight, working with the North American design engineers so that they actually knew how this equipment was going to be utilized, when it was going to need to be in certain locations during the mission. From this they could try and design the stowage and the installation such that it would meet all the mission requirements. I worked with their team, trying to give them insight into how we were going to actually use the hardware, helping them design to both the launch and on-orbit environment.

WRIGHT: Did you find them to be receptive to the information you were providing?

NYGREN: Oh, we'll get into this more as we go through some of this stuff, but every time you get NASA and a Tiger Team together, all of the badges disappear; all of the politics disappear. Everything gets focused on getting the job done and the team camaraderie [comes] together. Those guys were absolutely fantastic. They really were. I'm sure some of it was they realized that what they had built before had a problem, and they didn't want to have that kind of a problem again. They certainly wanted to solve the problem, but I don't think they felt that the

Borman Tiger Team or NASA was pushing it down their throat. It was that we, both sides, wanted to come up with a spacecraft that was going to do what we needed.

During this time frame, we had used what I will classify as flammable material, things like nylons and cottons. Beta cloth was created, which was a fiberglass-based material, and, yes, you can't burn it. It's burn-proof, but it sure didn't wear very well. It doesn't feel good when you're wearing it, and if you rub on it two or three times, it starts abrading, so it's not a very durable material. There were a lot of things to be considered in the design. What could we do? Could we use beta cloth, because it's soft and it's crushable, or do we actually have to use aluminum, because it's going to get stepped on would see wear and tear?

As far as the reception of the North American team, it was phenomenal. In fact, through the whole program, the Rockwell guys were always really, really cooperative. Then there's always the "how are you going to pay for this," when there's a change that you want to implement. "Well, you know, we built it this way. It meets all your specs, what you want is a product improvement." "How are you going to pay for it?" That's always there. It wasn't there quite as much in Apollo, when we had lots of money, as it was in the later programs.

But a great bunch of guys. I never saw any problems where they were having concern with what we were doing and how we were trying to help them.

WRIGHT: What length of time were you on this team? Or how did you transition from this team back onto your duties for Apollo 9?

NYGREN: I was probably out there close to nine months. I'd have to go back and look at my notes to get that accurate. It was probably eight or nine months that we were out there. Right

outside the Rockwell Downey facility, the main entrance is on Lakewood Boulevard, there's a little bitty hotel there called the Empire. I don't know whether it's still there or named the same thing, but it was the Empire Hotel then. The people at the Empire got to know us real well, because we were out there forever. I spent months and months in that hotel, and the Borman team worked just north of the Downey plant on Lakewood Boulevard. They were in a two- or three-story office building.

Once we'd pretty much finished the design work, under the Borman Tiger Team, I was pretty much back in Houston until they were ready to power up the spacecraft. Coming off of the line was spacecraft 101, which was Apollo 7, 102, which was Apollo 8, and 103, which was Apollo 9. I went back to Houston until they got ready to start actually testing spacecraft 103, and then I started traveling back out to Downey again.

WRIGHT: Tell us what you found when you went out there. Were all the ideas and the work that you had done previously instituted into your spacecraft?

NYGREN: Yes. I would say the answer to that is yes. But also, when I went back out, spacecraft 101 and 102 had already gone through a large portion of their testing, and my counterparts, who were working on Apollo 7 and Apollo 8, Ray Dell'Osso, the guy I mentioned earlier, was working 7, had worked out all the wrinkles.

WRIGHT: That was nice of them.

NYGREN: Yes, it really was nice of them. [Laughter] I would say that everything was beginning to fall in line by the third spacecraft. We knew what we wanted, and they had done a pretty good job of getting us what we needed.

Now we were concentrating on making sure that the unique aspects of the particular spacecraft were detected. You had to know the mission to know you had the right equipment and it was set up the way we intended it to be used, because we were using some of the Command Module equipment on LM-3. This was the first Lunar Module flight we had to do certain testing associated with this common equipment. There's a little device called a crew optical alignment sight, which is what the crew used as the docking aid for docking with the Lunar Module. We had to make sure that the COAS [crewman optical alignment sight] was properly installed in the spacecraft and was aligned with the LM docking target.

If you're not going to dock to the Lunar Module, you don't need a COAS. For each mission there are specific things that have to be checked. We were more aligned with these checks as opposed to worrying about did the lockers that we originally designed actually fit. Yes, the lockers were pretty much going to do the job. Every bulkhead wasn't built exactly the same every time, so you have to do a little polishing and trimming to get things to fit. The big issues had been pretty well cleared up by the guys working spacecraft 101 and 102.

WRIGHT: What were your thoughts when you learned that Apollo 8 was going to go before Apollo 9? You mentioned that the decision had been made to send Borman and his crew to the Moon, and it actually came before—.

NYGREN: The mission I was working on with LM-3 was never envisioned to go to the Moon. It was a low Earth orbit flight to check out the LM systems. From that perspective, it didn't bug me, but I thought it was fascinating. I was all for it. Elmer [L.] Taylor was the lead for Apollo 8, and they were a great bunch of guys, and I really enjoyed watching their enthusiasm of, "We're going to get to send this sucker to the Moon." That's lots of fun, because that's what you've been working all the time for. So it was really a good call. I think it was real motivating to the team to say, "We're pushing the envelope, but, yes, we can do this." It was a good thing.

WRIGHT: McDivitt's team had a long time to train, and so you worked with that crew quite a bit. Can you share with us about those final months before they were actually launched, how intense your schedule became, or how your schedule changed from those first days that you were spending out at North American, and then how you were interfacing with the crew, and how the crew was preparing, and all the things that were being done to get this ready for launch.

NYGREN: I'll take a shot at that. Every time I sit down and think about it, I think about three more things that I ought to mention. [Laughs] There's a side note here that's more on the personal side, that when we first started testing spacecraft 103, I was getting ready to go out to California for a few months for the testing. I'd been dating my wife for about nine months at that point in time, and I decided, well, I ought to figure out if I'm going to get married before I go to California or after I come back from California.

So I go over to her apartment. Of course, being an engineer, I'm really a romantic— I didn't call ahead of time, nor did I tell her what I was coming over for. I managed to catch her when she was coming back from the laundromat at the apartment complex, and I spring this

question on her. Then I get this story about, "Well, I really didn't even realize that we were actually going together."

I'm going, "Oh, what have I got myself into here?" [Laughs]

After a little bit more negotiation, she's going, "Well, you know I haven't done a lot of traveling in my life, and it seems kind of silly for me to miss the opportunity to go to California for a couple of months and stay here and work, so I think the answer is going to be, we'll get married before you go."

Of course, with all the planning and foresight that I had put into it, the date that I had to head to California and the date that I could get a marriage license in Texas were incompatible, so then we had to decide if we were going to get married in Las Vegas [Nevada] on the way out there. I had a bright yellow 1968 Chevrolet Corvette we were driving to Las Vegas. She has a bright yellow wedding dress she's going to wear, and she's sitting there hand-stitching the yellow flowers on her wedding dress as we're driving out to Vegas. We got married in Vegas by the Justice of the Peace. My parents and brother came down to the wedding. Then we had our little honeymoon, which is another story, but it was another one of those romantic things that engineers come up with.

We finally ended up in California, and we had an apartment where we stayed between two and three months. We finished up the testing and left for Houston. We spent about two weeks in Houston; we didn't have an apartment, so we ended up staying with her parents. Then we went to Florida, rented an apartment in Florida, and three days before we launched Apollo 9 my first kid was born in the Cape Canaveral Hospital. About a week before that, they actually moved the launch of Apollo 9 three days later. [Laughs] So I thought, "Well, that's really good, because if that kid had come on launch day, it would have been a real problem." Three days

wasn't easy, but launch day would have been a real problem. So there's a little personal side note to getting through the Apollo 9 part of the program.

Going back to the question about getting involved with the crew guys, let me take a couple of minutes and describe the intent of what the flight crew support team was really trying to do in trying to make everything work. The flight crew support team was the eyes and ears of both the flight crew and, to a large degree, the Flight Control Team and Training Team at the spacecraft development facility and at KSC.

When you're custom building these spacecraft one at a time, there are unique aspects to each spacecraft that aren't repeatable by another spacecraft just like it. What I mean by that is, is that when you turn a gauge on and you're looking at a particular band, in one spacecraft it might read between five and ten, and on the next spacecraft it might be six and nine or six and eleven. You're really looking for how does this particular spacecraft actually operate when it's turned on and it's functioning properly, with the intent of our effort being that when the crew are training in the simulators or in the mockups, we can provide to the training team the unique aspects of spacecraft 103 for the simulation. If the crew doesn't see it, we really didn't spend a lot of time on it. If it's a crew display, like some kind of a meter, we try to make sure that that particular meter reading is similar to what the simulators and trainers actually represent.

We would get that information into the Flight Control Team documentation, and the flight procedures, so that the right numbers are actually reflected in the documentation. What we would end up doing as part of our job is keeping track of how the systems and displays worked, and then just before launch we would go in and install what we called the crew preference decals or the spacecraft-specific decals. We would actually put little colored tape bands on the meters indicating that for this spacecraft and this set of metering, this is where the operating band (green

tape) is, this is where the off-nominal but still safe band (yellow tape) is, and this is the out of limits (red tape) area. We would install all of the decals just before launch. Then we would go back and take close-out photos to formally document the decal installation. We would make sure that the flight control documentation was actually reflective of the decals, and the flight data file had been updated. These procedures are the one the crew actually uses to fly the spacecraft.

We would work with the flight data file manager and say, "We put a decal here, and it says this, and we put a color band here, and it does that," so that we were sure that everything that we had done in the spacecraft was accurately documented in the flight and backup procedures so that the guys on the ground knew exactly what the crew was looking at. Our general goal was to make sure that for the spacecraft we were working, the crew knew how that spacecraft worked and what I will call the idiosyncrasies, that information was provided to the training team and flight team, so they knew exactly what they were dealing with on each spacecraft.

But every spacecraft and every mission were slightly different, so you had to go back and custom build it and check it again and again to make sure. We were really the eyes and ears of the flight operations element, looking at the flight hardware when it was being developed and when it was being tested. The crew guys had certain specific things that they wanted to do a certain way. You know, if you have a left-handed guy, he does things different than a right-handed guy. You have to customize certain things to the crew that you're actually working with. McDivitt, Scott, and Schweickart were intimately involved in a fair amount of the Downey testing, the crew compartment fit and function, and loose equipment bench checks.

At KSC, they repeated a crew compartment fit and function, because a lot of the times when you did the tests at Downey, you were using nonflight hardware, prototype hardware,

trying to make sure you were in the right ballpark. At KSC all of the flight hardware was available, so you wanted to make sure that the flight hardware actually did the same thing as your mockups and prototypes. We actually did a full-blown crew compartment fit and function, and we would go out and actually install all of the equipment in the lockers where it was stowed for launch.

The crew would look at it before it was stowed [bench check], so they'd know exactly where it was stowed and how it was packed. Then we'd go out and stow it in the spacecraft. We'd run the crew compartment fit and function to a mission scenario. The first thing you do is to have your cameras out the window for ascent, and so it's got to be set up before the crew ingresses the spacecraft. You start reconfiguring the spacecraft to take stuff down that you don't need anymore after the launch. You've got to reconfigure the seats. After you reconfigure the seats, you've got to take your suit off, so you would doff your suit and stow your suit. Then you would start going through the sequence of what the next activity was, whether it was doing some kind of an alignment with the stars, doing the attitude alignment, or maybe it was fix a meal.

We'd basically take the spacecraft mission timeline and look at it, and then lay out the test, what pieces of equipment needed to be used at a certain period of time, and we'd just functionally go through putting the equipment where it was supposed to be, and that we could access the next set of equipment that you actually needed. Now, we had obviously dress-rehearsed this in the mockups and the trainers in Houston, so hopefully we knew what we were doing. Interestingly enough, you'd always find something in the real spacecraft that you didn't simulate right in the trainers to begin with, and so there were the, "oh, that's how that actually works" kinds of things.

We went through that activity, and then the next major involvement was when we actually put the Command Module and the Lunar Module in a vacuum chamber at the Cape [Kennedy, Florida; the name was restored to Cape Canaveral in 1973]. For the chamber tests we put the crew in the spacecraft and actually tested the spacecraft in a vacuum environment. It was important when we did the chamber test to have all of the right equipment in with the crew, so they could operate the spacecraft and hook up all the electrical hardware. We were looking for EMI [electromagnetic interface] interference when we're running to make sure TV cameras or movie cameras or other electrically powered hardware weren't generating any kind of a problem for any of the systems.

We would work with the Cape guys in designing the chamber tests for how long we were actually going to run the chamber, and then what equipment we were going to plug in at what sequence. We would determine that by looking at the nominal timeline for the mission, and then we'd look at what equipment is actually on at the same time. Then we'd try and put a scenario together that at some point in time we would have all of the same equipment on in the same configuration that you would see during the mission, so that if there was any combination of equipment that caused a problem, you'd be able to identify that activity.

After the chamber tests we would concentrate next on what was called the countdown demonstration test, which was a full-blown dress rehearsal of the launch day. You would stow all the loose equipment in the different stowage containers and take it out to the spacecraft, stow it in the spacecraft, prep the spacecraft for the countdown, and the crew would get in their suits back in the O&C [Operations and Checkout] Building and take the ride out to the launch pad, go up to the spacecraft. We'd actually strap them into the spacecraft, close the hatch, do the countdown to essentially T-zero, and then we'd egress the crew and bring them back to the

O&C. This test verified that our launch day timeline was right, for suiting and transporting the crew, stowing the spacecraft, and that we had all of the right documentation in the right places in the spacecraft. We would go out and put in all of our decals so the crew guys could see them as they would appear on launch day.

We'd have a flight checklist. The ascent checklist would be out and available to each one of the crew guys. The commander had one, the Command Module Pilot had one, and the Lunar Module Pilot one. They each had their own checklist. That gave us an actual demo of how it was going to be for launch day. Then we started the preps [preparations] for the actual launch, to get all of the equipment lined up the way it would need to be for launch. A lot of people don't think that there is a lot involved in some of this, but you get into it, and then all of a sudden you're going, jeez, this is a lot more complicated than you thought.

One of the things that came to mind to me was on Apollo 9 during the mission, Dave Scott opened the hatch and actually stuck his head out of the hatch. We wanted to photograph this with a sixteen-millimeter camera. So, I've got a camera bracket that attaches to the handrail on the hatch. You take the handrail and you attach the bracket to it; then you attach the camera to the bracket.

You've got to figure out which lens you're going to put on the camera. You've got to figure out what the angles are that you're going to adjust the bracket to, so that you get the angle that you actually want. Then you have to go back and figure out where this will occur in the mission sequence, because then you've got to set the F-stop [focal length ratio] lens setting so that if he's in bright sunlight, it will work. Or, if he's actually going over the horizon where there is little light, you still get the right exposure for the pictures.

In just putting together the scenario to get a picture taken, there's an awful lot of work involved. Eventually the checklist has to say what is to be done before you get ready to go out for the EVA: you've got to unstow the bracket; you've got to unstow the camera; you've got to get out the film magazine; the film magazine has to be the right one, because it has to have the film in it that will be compatible with bright sun or whether it's a ASA [American Standards Association] level.

The proper lens— you've got to verify the settings on the lens, that you've got the right magazine installed. Then you've got to set the angles for the camera on the bracket and you've got to put it on the right hatch bracket. Everything has to be written in the checklist so that the crew member getting the equipment knows how to set it up.

When you start taking each activity and laying it out across a flight, there's an awful lot of details that have to be written down. It has to be dress-rehearsed. It has to be practiced. Then you have to do it with the real hardware to make sure that it actually is, in fact, going to work, because we find things that we thought were going to be just really simple, and they aren't.

In fact, this is the story that happened in Skylab. If I recall, we even had commercial, off-the-shelf tools, and we could find bolts that they didn't fit. You don't do that very often, but it happened to us, and I actually have at home a seven-sixteenths socket from Sears that doesn't fit anything. [Laughs]

That was kind of the scenario that we worked. I got to know the crew guys relatively well, Dave Scott, particularly. He was the Command Module Pilot, so I spent a lot of time with him. I did a similar function for the Lunar Module, up in Bethpage [New York, Grumman Aircraft Engineering Corporation, later Grumman Aerospace Corporation]. I can remember my first trip to Bethpage. That was an interesting experience. I was out in California. This is to tell

you how things have changed, but I was out in California, and they tell me I'm supposed to be in Bethpage. We're supposed to be running a test in Bethpage, and they need me up there to get a bunch of the crew equipment ready for it. I said, "Well, I haven't got a ticket to go to [New York]."

They said, "Well, fly back to Houston and we'll meet you at the airport, and we'll give you a ticket to go to Bethpage."

So I go, "Okay." I fly back. Sure enough, there's a gal at the airport. She hands me my ticket, and my next flight is a few minutes later. I get on that flight; I fly directly up to Bethpage. Well, I've never been to Bethpage before. I don't know where I'm going. I don't even know where my hotel is, but I know it's on the Jericho Turnpike. Well, I fly into [John F.] Kennedy [International] Airport [New York, New York], and I'm supposed to get on some road called Oyster Bay. I don't know where that's at, so I asked the rental car guy, "How do I get to this place?"

He hasn't got a clue, and says, "Ask the toll booth guy out there on the interstate."

So, okay, I go out there, and I ask this guy, and he just goes, "I don't know." He says, "I know it's out there, but I don't know how far out there it is."

I said, "Okay." So I take off. Well, I drive around, and I finally find Oyster Bay Road, and then I'm looking for the Jericho Turnpike, and I cannot find the Jericho Turnpike. I'm driving around, and it's late at night, and I'm driving, and I can't find this place. I finally find this water tower that says "Jericho" on it, so I stop at a gas station thinking, "I've got to be close." The attendant hasn't got a clue where the Jericho Turnpike is, but he knows that I'm in the town of Jericho.

I'm driving around and driving around, and I can't find my hotel, but I happened to drive by the Grumman plant, so I thought, "Okay." There was a little residential subdivision by the plant, so I drive out there. They had given me a Dodge Charger, a fastback car, from the rent-a-car place. So I parked in the residential subdivision, flopped the seats down in the back of the car, and went to sleep. [Laughs] Got up the next morning and went over to the plant. Drove in and found out where our office was located. Went up and asked the secretary to draw me a map to the hotel and told her I was going to be at the hotel for a couple of hours, catching up on a little bit of sleep. [Laughs] It was quite an experience getting to Long Island the first time and trying to find the hotel that I was supposed to be staying in.

But the Lunar Module was a little bit different, in that they had a hangar queen spacecraft [an aircraft that never flies] called LTA-8, Lunar Test Article 8, that we used to do a lot of the development work on. There was a guy that was working on the Lunar Module. He was the LM-3 systems guy, but he ended up working LTA-8 a lot, a guy by the name of Dave [David A.] Ballard. The crew interface was Fred [W.] Haise, [Jr.] on the Lunar Module at that point in time, and Dave Ballard and Fred Haise knew more about the Lunar Module than, I think, any two people in the world. They knew that thing inside and out.

I made a number of trips up to Grumman to do the crew station and the crew equipment layout for preparations for the Apollo 9 and the LM-3 activity, which included the crew guys ingressing the Lunar Module and activating it. LM-3 wasn't a lunar surface Lunar Module so I didn't have to worry about sleep restraints or suit stowage, because the suits were always going to be in the Command Module. There was a lot for LM-3 we didn't have to worry about, but the guys for the lunar surface Lunar Modules, they had a lot more difficult time figuring out where they would put all the gear in the cramped quarters.

I remember—this is one of my stories of, "Jeez, I probably could have gotten fired for that," but I was over in the Lunar Module mockup in Building 5 going through a stowage sequence exercise. George [M.] Low, who was the Program Manager, came over, and he wanted to get a briefing on the inside of the Lunar Module. He was sitting on top of the ascent engine cover. I was working above and behind him, working on the docking tunnel to show him how the hatch worked and how the probe and drogue were going to be moved. I actually dropped the hatch—it was on a hinge—dropped the hatch, and it hit George Low on the head and knocked him clear off the ascent engine cover. I thought I'd killed the poor guy. [Laughs] I was thinking, "This is career ending. This is not what you're supposed to do." Fortunately he took it in stride and got up, and we continued on. But it's one of those things that sticks in your mind, when you knock the Program Manager off an engine cover by dropping a hatch on him.

I had similar activities in the LM, the COAS, the Crew Optical Alignment Sight needed to be aligned to the Command Module targets and the cameras had to be set up during the rendezvous and dockings to shoot out the window and capture the Command Module images. Overall, I would say that probably 70 percent of my time was spent working the Command Module side of the flight, and about 30 percent was done on the Lunar Module side.

WRIGHT: Two totally different pieces of spacecraft for you to work on.

NYGREN: Yes. Yes, but as far as the equipment was concerned, a lot of it was the same. The cameras were the same. The COAS essentially was the same piece of equipment, so there was a lot of commonality in the hardware. How it was used in the spacecraft and how it was set up was totally different, and the Grumman team was a different group. I don't know what it is, but

the people in California are different than the rest of the world, I think. They were really cooperative in trying to solve all the problems that we had at that point in time. They were a good team, also, but they were different. People in New York and people in California, there's more than 3,000 miles of difference in how they think. Then you throw a Texan down there in the middle of it, and that makes it all that much more complicated. [Laughs]

WRIGHT: And a young one, at that, because we're still talking right out of college. This is a couple of years after you graduated?

NYGREN: Yes. Yes. Actually, I graduated from college when I was twenty. Northrop went on a quarter system, so I entered and I went twelve straight quarters. I never took any time off. I ended up graduating just before my birthday, and I was twenty years old. When I started work at NASA, I was twenty-one by two weeks; 5th of July versus starting on the 16th, I think, so a week. I still think that when I was on the Tiger Team and when I was doing some of the crew station work, I had more authority and responsibility than I did when I retired thirty-five years later.

You think about that; how does that work? Well, when you were working on Borman's Tiger Team, you were out in California. They had teletype machines and the rudiments of fax machines, and they had four-button telephones, but there wasn't a lot of management out there. It was you. You'd look at the drawings. You and the North American guys would look at it and say, "Yep, that's it," and you'd sign off on the drawing, and it was a done deal. They'd go start cutting hardware.

Today you have cell phones, pagers, e-mail. Trying to get a decision made is next to impossible, because everybody gets involved. How misused is e-mail, in that you'll send an e-

mail, and you'll address it to four guys. You really only want one of them to do the work, and the other three are supposed to be information only, but you don't address the e-mail that way. Then everybody gets in the act, and nobody knows who's responsible. Although there's an awful lot of advantages to the technology, I think it has taken away from pushing the decision making to the lowest level possible. It has forced the decisions to be made much higher, just because the information flows to management. Where engineers used to make decisions and even Section and Branch Chiefs didn't know about it, now it is likely to get to the Administrator or on NASA Watch [Website devoted to information pertaining to NASA, not an official NASA Website].

How do you make a decision anymore and get it to stick? There's so many people who can say no and so few people who can say yes, and make it stick. But you weigh that against the fact that you get the information instantaneously, which has lots of advantages. It's just making sure you use all that technology to your own ends and make it work for you.

WRIGHT: You mentioned that you and your wife and your brand-new baby were at the Cape area when the launch of Apollo 9 occurred. What were your duties during the days prior to the launch and, of course, while Apollo 9 was launching?

NYGREN: In preps for launch it's basically making sure that all of the crew equipment is ready to go. You start making sure you have all the loose equipment at KSC. You've got to have all of the food, and it has to be packaged right. You have to have all of the camera gear tested and certified. All of the film magazines have to be loaded, and they have to be identified with what kind of film is in them and, in certain cases, specifically in what sequence that magazine is

supposed to be used. You have to make sure that all of the personal hygiene equipment is configured properly, the crew optical alignment sight is aligned and is functioning properly. You go through and you get all of the equipment and you make sure that it's all functioning properly. You test it on the bench and make sure it's working right.

Then you prepack all of the equipment that is going to be stowed in lockers for launch, the food, clothing, etc., is all prepacked for launch. Then the equipment that's actually going to be used and installed. Like some of the cameras are installed for ascent, shooting out the window, and you get this equipment prepared. You get all the paperwork ready for transporting the equipment to the spacecraft, and get it installed in the right location. Everything that you do anyplace in the space business is done on paperwork. So if you want to go fit-check a camera to a bracket, you've got to write a piece of paper.

It starts off with knowing what hardware is going to be used; remove it from bond. Then you've got to get it from a bond room to the clean room. Then the paperwork states each step you're going to take with the hardware, and certain steps have to be stamped by an inspector certifying you did the things that the paperwork said you were going to do, documenting what you did. Then you return the hardware to bond, and they inventory it.

There's a huge amount of paperwork that's associated with anything that you do, and if you're just going to do something on a bench, you can generally do it on what's called a Test Preparation Sheet, a TPS, and those are simple things that you want to do. For more extensive tests, what they use at KSC is what's called an OMI, Operations and Maintenance Instruction. If you're actually running a longer test, you actually have to write an Operations and Maintenance Instruction. It is used for more complicated tests and it has a more formal review process, so that you make sure that all of the right people get involved.

There's a bigger review cycle for Operations and Maintenance Instructions, but pretty much, we check out all of the equipment and we get it ready for flight. A lot of that's done on test preparation sheets, but the actual stowage into the spacecraft is done on an OMI. You actually write an OMI that says to take a particular piece of equipment and mount it in its launch location and tighten it down per specs [specifications]. Some of it is bolted in; you have to torque it down, other hardware might just use quick-release pit pins, but you have a procedure that tells you how to sequentially stow everything in the spacecraft.

Next, we work on the decals and color codes I've been mentioning. We have drafted up what we wanted, then we would give it to the flight data file organization. They would work with the decal lab and have all of these decals made up for us. We would have the decals sent to KSC, and we would go through all of the decals and make sure that they were all written exactly the way we requested.

Then we'd write a TPS to go install them in the spacecraft. There are two kinds of TPSs. There's a Type A and a Type B. If you want to take a piece of equipment out and run it and put it back, you write a Type B. If you want to change the configuration of something, then you've got to write a Type A TPS. Again, it takes more review and approval on a Type A TPS. Since we were actually changing the configuration of the spacecraft by installing these decals, we had to write a Type A TPS, and it would call out each decal and exactly where we were putting it. It would call out that you had to take a closeout photo of the decal installed.

We would go out a couple of days before the launch, and install all of the decals that the crew wanted in the spacecraft. We'd take all of the closeout photos, and then send them off to the lab. We'd keep a set of the photos, and we'd give a set to the flight data file guy so they could start making sure the flight checklists reflected the decals we installed. We'd also send a

set back to the flight control team in Houston so that they would have a set on console in case there were any questions.

Some of the decals were really nice, those nice foil ones that you'd stick right on a panel. Others were made with a piece of gray tape—looked like duct tape, but it wasn't duct tape. We'd rip off a piece of it and we'd stick it on the panel, and then we'd write whatever we needed on the piece of gray tape. [Laughs] It would probably be something that was associated with the ascent, that this switch would function this way for ascent, but for entry, it might function differently.

For the crew suiting activities, they have a lot of equipment in their suits. You've got to make sure that the suit itself is properly configured and functioning. In their suits they have their checklists, their emergency procedures, pens, pencils. They wear a watch and at 0-dark-30 on launch day we'd call up the national time standard and set their watches. It has to be done to make sure that everybody is working on the same time.

We would brief the crew a day or two before the launch on what all we had done in the spacecraft, showing them all of the closeout photographs.

Anytime you launch something like a Saturn spacecraft with the Command Module on top of it, not everything is working. There are certain things that aren't working, so you brief the crew on what things aren't working and what you don't expect to be working for launch, but by looking at it you can conclude whether or not it is a problem for our mission. It may be something that you only need for a lunar landing or something like that.

Then for launch the job was find the best place you could find to watch the launch. Didn't have to sit on console. For the Apollo flights, we always got invited to go to the family viewing site, so we got to go out and visit with the crew's family and watch from where they

were. The family viewing site was just out in front of the VAB [Vehicle Assembly Building] facility.

As it turns out, I worked Apollo 9 and 12, but I was at KSC for every manned launch, from Apollo 7 to STS 26. For the launches I wasn't supporting, I still wanted to go watch them. I'd go watch them. I'd stand in front of the VAB, and that was really impressive, because the Saturn V with the liquid engine—and I'm not smart enough on the physics that's associated with this—but with the liquid engine, the launch is much slower than a Shuttle launch. But the acoustics of a Saturn are phenomenal, and you could stand in front of the VAB, and the Saturn has a pulse to it. [Imitates sound.] You could feel this pulse [pressure wave] hitting you, coming off of the launch, but when you stand in front of the VAB, it would bounce off of the VAB, and you could feel it hitting your back. [Imitates sound.] It was phenomenal.

I always wanted to stand in front of the VAB for launch, because it really gave you a unique sensation when the Saturn was lifting off the pad. You'd see it light off. You'd see it start lifting off. Then you could actually start feeling the acoustical part of it, because the sound travels a lot slower than the visual. You could begin to hear it building [imitates sound], and then you'd start feeling the pressure wave [imitates sound]. Phenomenal. It's very difficult to describe, but it is absolutely unique, and you can only get it standing in front of the VAB, because otherwise you can feel it going by you, but you don't get the bounce-back off of the VAB behind you. That was part of the deal, being at the VAB for a launch. [Laughs]

WRIGHT: And quite an experience of knowing that, at least on the Apollo 9, that you were just up in that capsule doing some of the work.

NYGREN: Oh yes. Let me tell you about my experience on stowage for Apollo 12. When you do the stowage, the Mobile Service Structure [MSS] is at the launch pad. The Mobile Service Structure is a big mobile structure that comes up alongside the spacecraft and it gives you access to all of the booster, all the way up to the Command Module. Most of the time you get all your access off of the Mobile Service Structure [MSS], because it's a more friendly atmosphere than going over to the launch pad and going up the launch tower and then going across on the swing arms. On the MSS, you can go up the elevators, and they've got big platforms so you can lay out your equipment, and they have bunny suits [white suits worn to prevent contamination of the inside of the spacecraft] needed for accessing the spacecraft.

We were stowing the spacecraft for Apollo 12. Then something came up and we couldn't finish, but we only had three or four things left to do, and they were nits. I ended up being the guy that stayed up there in the spacecraft, and everybody else left. Finally, finally, they say, "Okay, we're ready for you to finish." In the middle of all of this, there was some weather, and you couldn't get in or out of the spacecraft because of lightning, so you had to stay in the spacecraft.

I finally finish, and I'm leaving, "Wow, it's time, you know. I've been in the spacecraft for hours and hours." I get out of the spacecraft, and to go to the Mobile Service Structure, you go through a door to the right when you get out of the spacecraft. Well, I hit this door, and the thing is locked, and I can't get out. I'm pounding on this door, and I can't get out for the life of me. I look out of a four- or six-inch square window in this door, and I'm looking out there, and the Mobile Service Structure is back at the perimeter fence. It's 500 feet straight down, and I'm thinking, "I'm glad those guys locked that door," because I'm trying to bust out of it, and my

clothes and everything are out there on the MSS at the perimeter fence, and I'm looking down 500 feet, going, "This is really good that these guys locked that door." [Laughs]

Well, here I am in my bunny suit, and all my clothes, my wallet, my badge—well, your badge isn't up there, because your badge is actually in a badge board at the perimeter. When you're going to the launch pad you take your NASA badge and exchange it with a badge that has a number on it. This way they can keep track of who's inside the perimeter if there's any kind of an incident. You can't take your number badge in the spacecraft. You have to leave it with your clothing on the MSS.

Well, the MSS is outside the perimeter fence, but my picture badge is in that slot. I haven't got a numbered badge to put back in the slot to get my picture badge back. So that takes a round of discussions with the security guys to figure out how we're going to do this, and they're going, "Well, do we really believe his stuff is up there, or is this guy some kind of a flake?"

I finally get through that, and then I get to the Mobile Service Structure, and it's on the transporter, and nobody, unless you're on this guy's checklist, can get on the crawler when it's activated. Certainly you can't ride the MSS elevator clear to the top. [Laughs] I'm trying to figure out how I'm going to get my clothes and other stuff off of the MSS. I don't remember how long it was, but I remember it was a long time before they finally agreed that they'd let me get on the crawler with one of their guys, and they'd run me up to the top of the MSS so I could get my stuff.

For launch, we were watching and I didn't have any real responsibilities at that point in time. During the mission, we really didn't have any real responsibility, either. Right after

launch we generally got in contact with the landing and recovery team, and told them what and where we had stowed the different equipment.

Then we essentially were on call during the flight in case something didn't work, or they couldn't find a bracket or couldn't find their breakfast. We were on standby to help them find anything they couldn't locate or help them fix something that didn't work.

One of the other things we did early on in the program—it got more formalized later on for some different reasons—but the crew was authorized a personal preference kit [PPK]. They get like three-quarters of a pound of personal items that they can take, mementos for themselves or for family and friends. Then there was an OFK, Official Flight Kit, that the agency flew, and we were responsible for packing these kits and verifying that the items got cleaned to the cleanliness specs, and if an item was flammable, that it got blessed.

We'd write the test preparation sheets that gathered all of the kit items and transferred them into bond to get it "legal." We'd write the TPS, Type A type, to pack it for launch. We worked with the crew guys on all of the pins and medallions and flags and whatever they wanted to fly. A couple of nights before launch, we're in the crew quarters with all the kit items spread over the beds, going, "Okay, now, this is Dave's, and this is Jim's, and this is Rusty's," or on the next flight, "This is Pete's. This is Dick's," you know. [Laughs] We would organize it in the bag for each guy, keeping track of each item, because there were a lot of personal items people would fly—wedding rings, items that were important. You needed to make sure that whichever crewman was flying the item knew who he'd actually received it from, so he could get it back to the right people after the mission.

Postflight, we'd get the kits back. We'd take the kits back and clean the items up, because a lot of this stuff was small, and had been wrapped in the world-famous gray tape—it

was gray tape back then, and it was like duct tape is today; it solved everything. [Laughs] We'd work with the crews to disposition the items after the flight. Most of the time this was just getting the items to the crew, and they took care of returning them.

WRIGHT: Did you see the Command Module when it returned?

NYGREN: No.

WRIGHT: Okay. So once it went, that was the last you saw it.

NYGREN: Last I saw of it.

WRIGHT: Moved on to your next project.

NYGREN: Went to the next project. One of the—I believe this story to be true, but I haven't actually gone off and verified it—but I talked to you about putting all these decals in the spacecraft. Well, this was on Apollo 11, and my counterpart on Apollo 11 was Ray Dell'Osso. He was in the spacecraft, and when you're in the spacecraft the displays and control panel is over you, and the lower equipment bay is by your feet. He's supposedly laying in the seats writing on the display and control panel when his pen quits writing. [Demonstrates hand movement of shaking a pen.] He starts shaking his pen and dots appear all over the spacecraft. [Laughs] All over the displays and the control panel and the lower equipment bay. I think if you actually went

and looked at the spacecraft, you'd probably be able to see some of those spots, but they did the best job they could to clean all the panel surfaces.

WRIGHT: Left his mark. [Laughs]

NYGREN: You only get so much time in the spacecraft to install the decals, and now he's going to have to go out and say, "I need some cleanup equipment in here." [Laughs] So, you know, there's been a little incident.

There was one when I was doing Apollo 12. I was working with the PPKs and the OFKs, one of the things that they always flew with was a bag of silver medallions that were stamped for the particular flight. I had all of the PPK items packed up, and I needed to fit-check it where I was going to stow it to make sure it would fit, because there was like seven or eight bags. They're not big bags, little four-inch diameter, six inches long or so. My spacecraft was out at the launch pad, and I didn't feel like trying to go out to the pad because it's a big hassle, but Apollo 13's Command Module was down in the high bay. So I said, "Hey, I could write a TPS and go fit-check it in that spacecraft. I wouldn't have to go all the way out to the pad."

I write out all my paperwork, grab all my bags, and I run down and give the test conductor this sad tale about why I needed to do this fit check. He says okay, go do it, and I go off and I get in the spacecraft, and I check everything, and everything is great. I grab all my bags and I take off. I've got all these bags; throw them back in my locker. A couple of days later I get this phone call from the test conductor, and he says, "You need to come down here."

I go, "Why?"

He says, "I think we've got something of yours."

And I go, "What do you mean?"

He says, "I think we found something when we did the tumble test." In the tumble test, they take the Command Module and move it in all kinds of attitudes to try and get any particles, little dirt, loose screws, anything that comes loose out where they can clean it out of the spacecraft. He says, "We found this thing during the tumble test."

I thought, "Oh, jeez. Okay." So I go down and he's got this bag that's full of those silver coins. It's been banging around in this spacecraft as they're doing this tumble test. [Laughs] I figure, one, "How did I ever get by with getting out of the spacecraft without having all the bags?" because they check everything that goes in and goes out; and, two, not really breaking something with that bag, because it had to weigh three or four pounds, flopping around in there. But, to say the least, they weren't too enamored with me when I had left the bag in their spacecraft, and it flopping around. [Laughs] It may be another one of those side stories, more of the personal interest than the actual technical work being done.

WRIGHT: It's a good combination to hear.

NYGREN: Yes. That kind of recaps what we did, how we did it. We had a great bunch of guys. For whatever reason,—well, there is a good reason. Whatever you're doing in the crew station with crew equipment, it's always the lowest priority activity. If you're actually doing a real test with power on the spacecraft, that's important. This crew station work, it's secondary. Invariably you'd get to the spacecraft at midnight or two in the morning to find out they were doing higher priority work.

You'd say, "Okay, I'm going to have a good time and I'll see you in the morning."

Well, just about the time you're in the middle of this good time, they call you up and say, "Hey, we're going to give you three hours in the spacecraft, and you've got to come back out."

You go, "Oh, man, why are you going to do that to me?" Then you go out, and something would come up, and you're always delayed and delayed.

There was a guy down at the Cape by the name of Ernie Reyes, and Ernie was the schedule guru. Every day they'd come out with their seventy-two-hour schedule, and in the corner of the schedule he would draw some kind of a little cartoon; generally, it was some kind of little Snoopy cartoon. He was just unmerciful on the crew equipment, crew station guys, who are always late. We could never get out of the way when it was time to get out of the way. We were always behind in some form or fashion. They couldn't find us when they needed us to go do something.

You always came in and looked at the seventy-two-hour schedule that they'd published and hoped your group wasn't the one that managed to make Ernie's cartoon for the day. [Laughs] But he was famous for his cartoons. In fact, there's a book of them around someplace. He had put them together for each one of the flights, and you could go back and figure out which group didn't perform stellar that particular day. [Laughs]

WRIGHT: Which one resembled your group, huh?

NYGREN: Yes, exactly. Exactly.

WRIGHT: We just finished talking about your activities with Apollo 9. Of course, [Apollo] 10 came next, and then, of course, the first lunar landing, Apollo 11. Although you didn't have any

official duties with it, could you share with us where you were and what you were doing during that time period, and your thoughts of the actual landing on the Moon?

NYGREN: Yes. As it turned out, when Apollo 11 was launching, Apollo 12 was at KSC, so I was at KSC for the Apollo 11 launch. It was one of the launches I stood in front of the VAB for. My job then was really just supporting the Apollo 12 prelaunch preparations, working with Pete [Charles Peter] Conrad [Jr.]—or, let's see, Apollo 12 was Conrad, [Richard F.] Gordon [Jr.], and [Alan L.] Bean. We were probably in about the crew compartment fit and function time frame. As far as Apollo 11 was concerned, Ray Dell'Osso was, again, as I said, the crew station, crew equipment guy, and I knew him well since we had roomed together previously. I didn't have any real responsibilities that were associated with Apollo 11. For the mission I was at KSC, doing test and checkout. Got to watch the landing and listen to it at KSC on the TVs.

Like everybody else, you're just so elated that it was working so well, all of the work that you had put into it. The flight seemed to go extremely well, from everything that I was seeing, which was like the general public, but if you talked to the folks who were in the Control Center, there were a lot of things on the Lunar Module that were right on the hairy edge when the software computer was being overloaded, and what to do about that, and whether we could continue to land or not. There were a lot of people that were really excited, because the stress and pressure was on, because they were seeing things with their systems that they didn't want to see.

But to the rest of us, we're all standing out there, thinking it's all going just as well as it can go. It was just a great moment in history, and very fulfilling, in that all we had done as a

result of the fire and how fast we had worked to get the spacecraft turned around and fixed, and the fact that it actually came together as fast as it did was phenomenal.

I would say that it's one of those things in history that you just didn't get a chance to spend the time thinking about it, because Apollo 12 was next. Yes, Apollo 11 was up there, and those guys are doing their thing, but we're doing our thing, also, trying to get the next spacecraft ready to go fly. You'd kind of look and say, "Yea, verily," but you didn't get a chance to stop and really take it all in. It was, "Yeah, it's happening, but the next one's coming down the pike, and we're going to be just as successful, so we're going to concentrate on it." And we just kept pressing.

WRIGHT: And you were. The mission was very successful, and you had a completely different team to work with, crew. If you could, share with us how the differences and how the similarities were with this preparation—of course, the big difference was that this mission was going to actually land on the Moon—and so how your role has changed, if any, and how working with this crew was different from working with the first one.

NYGREN: From my own perspective, probably the biggest difference was when I did Apollo 9, I was the crew equipment engineer for both the Command Module and the Lunar Module. For Apollo 12, I was the crew station engineer and the crew equipment engineer for the Command Module, and really didn't work the Lunar Module at all. I didn't have any Lunar Module responsibilities.

The interface that we had with the crew, or I had with the crew, I had a really good rapport, I think, with both crews. I had a great rapport with McDivitt and Scott. Rusty

Schweickart, I also had a good rapport with. In fact, Scott [R.] Millican and myself tried to get together with him. He lives in The Netherlands now, in The Hague, and I was over there a couple of years ago, and we tried to get together, but we couldn't swing it.

It was kind of interesting, because I guess being one of those young guys that just came out of this practical engineering school and Rusty being a real scientist, I always had a hard time talking to Rusty at a level that I could understand. He always seemed to be about two levels of education above me. He was talking terms that I didn't really understand. He was a really neat guy, and I really enjoyed working with him. He was the one that I had to make sure I knew what I was going to talk about when I went to go talk to him, because otherwise we'd get off in a discussion where I wasn't comfortable. [Laughs] Conrad, Gordon, and Bean, they were really a great bunch of guys.

Some of the side notes on other activities—with Pete Conrad, I got to know Pete really well, and then in later life when he was working for McDonnell Douglas [Corporation], he actually drove in the Long Beach Grand Prix [California]. Toyota sponsored a Pro-Am [Professional-Amateur] race where a bunch of guys would get out there with souped-up Toyota Corollas and drive the race course. Pete invited me to ride with him as his passenger, and I remember we were out there. I got the opportunity to meet Gene Hackman [professional actor]; he wouldn't remember me, but he and Pete were going down the straightaway on the Long Beach Grand Prix, and they're banging their cars together. I'm thinking, "Holy cripes!" because I'm in the passenger seat, and these guys are going a hundred miles an hour, just having a ball, the time of their life. I'm out there, white-knuckled, hanging on, thinking, "What have I done to myself? Why am I out here?" But we went on, and Pete and I met off and on later in life.

Dick Gordon, I got to know him real well. In fact, I don't know if you have seen them or not, but the Apollo 12 crew had matching Corvettes. They were black and gold, and they had "CDR" [Commander], "CMP" [Command Module Pilot] and "LMP" [Lunar Module Pilot] written on them. In fact, Al Bean's is over in the Space Center, Houston, right now. It's on display.

Well, anyways, as we got ready to go to Florida, Hurricane Camille had just come through the Gulf Coast, and it was essentially obliterated. Dick asked me if I'd drive his Corvette down to Florida for him. So I said, yes, I'd drive his Corvette down for him. Well, I-10 [Interstate Highway10] was essentially wiped out, and we were on all kinds of back roads and detours trying to get to Florida.

I have this one story that I was driving along, and I needed to get some gas. I stopped at this gas station, and honest to God, it looked like it should have been blown over in the hurricane, but it hadn't. It was an old, old, old wooden building, and it had the oldest gas pump I had ever seen. I stopped to get gas, and this elderly man comes out to help me out, and we get to talking. He goes, "This is one of those European sports cars, isn't it?"

I go, "No, no, no, it's not."

He says, "What is it?"

I said, "It's a Chevrolet Corvette."

He says, "Sure don't look like no Chevrolet I ever saw before." [Laughter] So he got his first experience with an American sports car.

One of the things that they did during Apollo 12, and some of the other teams also did it, was have an astronaut baseball game against the KSC contractor team. The astronaut team was always trying to find people to be on the astronaut team, and the flight crew support teams were

always down there, so we got to be on the baseball team. I think, as I remember, Conrad was pitching, and Gordon was catching, and we were all playing in Cocoa Beach [Florida]. Chuck [Charles J.] Tringali was the team lead for that particular flight. He was an Air Force detailee.

We were all playing, but when the game is over the kids come running out on the field wanting you to autograph their baseball. They really want the astronauts' autograph. They don't want some flight crew support team guy's signature. [Laughs] So you're out there, trying to get the kids to the astronauts, "These are the astronauts you really want to go get," but the kids are so excited you end up signing all of these baseballs, and these kids are sitting there going, "Who is this guy on my baseball? I can't figure out who this guy is that signed my baseball." [Laughs]

Al Bean, he was a Lunar Module guy, and I didn't work quite as much with Al. I got to know him pretty well, when he flew Skylab and I worked with him extensively. Great guy, great artist. He's a fantastic artist.

The Apollo 12 work was basically the same. We had the crew compartment fit and function. We had the altitude chamber test. We had the countdown demonstration tests. Back in those days, they had two sets of simulators. One set was at KSC, and one set was in Houston, and the flight data file guys moved back and forth.

John [W.] O'Neill, Tommy [W.] Holloway, Dan [Daniel A.] Bland, all book managers that we dealt with extensively. Having a lot of the training and the book managers right at KSC helped get things done a little bit easier. The mission was about the same. Nothing really unique, necessarily, about Apollo 12.

WRIGHT: We were talking about how many people it took to do the stowage. You had mentioned about four or five. If you could, tell us what those positions of those groups of men were doing.

NYGREN: Yes, sure. Generally, when we were working with the crew equipment, prepping it for a stowage exercise, or actually prepping it for launch and packing the containers, there were generally four or five of us. There was myself representing the flight crew and the Flight Crew Office activities. There was a Kennedy crew equipment engineer, who was responsible for the Kennedy aspects of it, and they actually owned the operation. They owned the facility and the contractor was a Kennedy contractor, so the KSC person was the lead in that aspect. We were the ones directing what needed to be done, but they were the owners of the facility, the base operator type of person. There was a contractor representative that was actually the engineer that had done the drawing and was what I would consider the true author of the actual stowage procedure, the OMI.

There was a tech [technician] that was responsible for actually putting all the little pieces together and verifying that it was done right. There was always a quality person in the area, looking at what we were doing, only certain pieces of it did they need to stamp off and really look at. There was always one in the area, because there were certain activities we needed them to witness and to stamp off. There are what they call MIPs, which are mandatory inspection points, where the inspector verifies the work performed was done properly. The inspectors generally stayed right with you and were on top of what you were doing.

But it was a good bunch of folks. One of the first folks that I worked with at KSC was a gal by the name of Ann [D.] Montgomery. She was the Kennedy lead engineer, and she and I

worked well together for a long, long time. She moved up and did well at the Kennedy Space Center. In fact, I think the last time I actually saw her, we were in the airport in Munich [Germany]. We were both going to the Space Ops [Operations] conference.

WRIGHT: While you were standing out by the VAB watching Apollo 12 launch, were you aware of the lightning strikes?

NYGREN: You knew that there was a flash. You didn't know that it actually hit the spacecraft, because it was in the deck [clouds], and you could see that there was a flash, but you didn't know if it went to the ground or whether it went to the spacecraft. So, yes, you knew something had happened, but you had no clue, and the engines kept going, so you really didn't know. So, no, I didn't know it hit the spacecraft. All I knew is that there was a lightning strike.

Then, just jumping on, this Elmer Taylor that I've mentioned a couple of times, he was—I can't remember which flight he was actually on. But anyways, through some kind of a deal, he had won like three free nights at a hotel down in Miami [Florida] for four people, so he and his wife and Phyllis [Nygren] and I took off and drove to Miami.

It turned out that we were driving down there during the night Apollo launch. We were about halfway between Cocoa Beach and Miami when we pulled off on the side of the road to watch the launch. The launch was just absolutely spectacular, just unbelievable, being as far away as we were, and the Moon was dull compared to how bright that Saturn V was in the sky. It just lit the sky up, just unbelievable. From that angle, arching out over the ocean, you could actually see the trajectory, where when you're at KSC in that area it looks like it's going straight up.

WRIGHT: A perfect ending for you.

NYGREN: Yes. Stopped and watched that, and then headed on down to three days in Miami, free, and it turned out to be a great time in Miami, so can't complain about that.

WRIGHT: Sounds like your wife made a good decision about that travel. You know, for a reason to get married, to have some travel and get—

NYGREN: She has some really good stories, and she has some really bad stories. Once I invited her to go down to the Cape. We were down there and—oh, I can't remember how long I was down there, but it was at least three months, and I got one Sunday and one half a Saturday off. The rest of the time I worked. Every day I worked, and she had two little kids, and she said, "I'm not doing that again. I'm not going to be away from my home, trying to take care of two kids, to be able to see you for one and a half days over a three-month period." So she quit going to Florida. [Laughter] She went back out to California one time with me when I was working the Oribtal Workshop. She went out for a period of time, and we had a place in Newport [CA]. But she didn't go to Florida. She said, "No, the work's too intense down there. There's no time to go do anything."

WRIGHT: Well, of course, before you went to ASTP [Apollo-Soyuz Test Project], you got transitioned to Skylab. At what point, when you were working with Apollo 12, did you learn that you were going to Skylab?

NYGREN: It was after I'd completed Apollo 12. The management was looking at how they were going to staff up and start supporting Skylab, and continue to provide support teams for the subsequent [Apollo] 13, 14, 15 flights. They needed to start supporting Skylab, and I'd just come off a flight and had the choice to go on to another—I don't know if I really had that much of a choice. I volunteered to do the Orbital Workshop. I came to them and said, "You know, I've done a couple of Apollos, and Orbital Workshop is starting up, and I'd like to do the Orbital Workshop, if that's okay with you guys."

At that point in time the Section Head was a guy by the name of Ed [Edwin W.] Hoskins, and Ed said, "Works for me." He started forming up the team, and because different guys rolled off at different periods, the team built up incrementally. We didn't have a team until Elmer Taylor ended up being the lead for Skylab. I was the Orbital Workshop lead. Ray Dell'Osso was the MDA [multiple docking adapter] and airlock lead, and then they assigned crew guys to each one of the vehicles, also. Dick [Richard H.] Truly was the Orbital Workshop lead, so I worked with Dick Truly, and then the airlock and MDA was Bob [Robert L.] Crippen. They also had an astronaut, Bill [William B.] Lenoir, who was assigned to the Apollo Telescope Mount [ATM], but because there's no crew station associated with that, we didn't have a flight crew support guy directly supporting the ATM. We had some systems guys working on it, but not somebody that was on the flight crew support team.

Between the three astronauts and Elmer and Ray and I, we basically formed up; the NASA part of the team, and we had a contract with Martin Marietta [Corporation] to supply us with engineering contractor support to help us do the job. I had four or five guys from Martin Marietta that helped me. Most of them actually worked on the experiments more than they

actually did the crew station, but because the experiments were so integral a part of the crew station and the mission for Skylab, they evolved into being on the flight crew support team and helped us with everything. They were really good guys.

One of them, J. P. Cottingham left and went to work for a cable television outfit and ended up being a Senior Vice President for Time Warner. Another one, Harvey Brandt was probably the real interesting one of the group, but anyways, when we finished Skylab and Martin Marietta really started phasing down, he started his own truck business where he would buy truck frames and then put whatever body you wanted on, either a box or a tow truck or a garbage truck or whatever, so he would build the truck to your specification. It turned out to be a very profitable business, so he did good. A guy by the name of Don Jones continued to work for Martin Marietta.

The Skylab activity was a little bit different—well, it wasn't a little bit; it was a lot different, in a couple of aspects. One of them was the management. Where Apollo, the program management was all at the Johnson Space Center, Skylab, all of the program management was at the [NASA] Marshall Space Flight Center [Huntsville, Alabama]. The two Centers think differently, manage differently, have different cultures, and where, with the astronauts being at JSC and the program management being at JSC for Mercury, Gemini, and Apollo, there had been a rapport established with how astronauts got involved in factory testing and how they got involved at Kennedy in testing, and how the flight crew support team performed certain functions in support of the crews.

Where this support was part of the culture at JSC, it was totally new to the Marshall guys. It took a lot of work with the Marshall management and with their contractor management to establish the rapport and actually allow us to perform the flight crew support function. Once

they saw the benefit of what we were doing and why we were doing it, we got their buy-in. It took quite a while to get their buy-in. They were not willing recipients of what we were trying to do to begin with. They worked with us over a long period of time; finally they understood and appreciated what we were doing; and at the end, they were really great supporters.

I think that as a result of that, when Spacelab came along—Spacelab was a Marshall-developed module, in conjunction with the Europeans—the people that worked Spacelab were people who had also worked with us in the Skylab days. We didn't have anywhere near the same kind of problem as we had before. They were looking for our support, wanted our support, wanted to get us involved, wanted to take advantage of what we brought to the table.

So it was really a nice environment, there were some rough roads in the beginning—I've mentioned, to begin with, that when we were out in California at the Downey facility, we had offices for the astronauts and the support team. When we started going to the Orbital Workshop at Huntington Beach [California], we didn't have anything. We didn't even have a desk to sit at. We didn't have a telephone. Took practically an act of Congress to get a badge to even get on the facility.

So we had to go through some hurdles, and there are a couple of side notes. Because we didn't have anything, we were starting from scratch, so we finally started working with trying to get some office space. It turned out that one of the senior managers from McDonnell Douglas was a guy by the name of Paul Buchanan, and Paul was part of the astronaut MOL [USAF Manned Orbiting Laboratory] Program, which was also where Crippen and Truly had come from. So there was a good personal rapport there.

Through the efforts of Paul Buchanan, working with the Marshall management, they finally managed to find us an office, and we ended up right on a walkway between two

buildings. They just put us in the middle of a hallway and put up a couple of partitions and said, "This is your office."

Then we got into the, "Well, that's nice, but it would really be neat if we had a secretary." So we needed to try and find a secretary. Well, Paul went out and found us a secretary, a gal by the name of Vicky, and she was a very, very attractive young lady.

As the time evolved, we decided we would like to have our own coffee pot fund—the only coffee available was from vending machines. The Air Force resident office that was there had their own coffee urn, so we asked if we could do that. Originally they said no. Finally they decided that they'd let us have this coffee urn. Well, the coffee urn, you got from the executive cafeteria, and they'd bring it up, and it was like a forty-cup urn.

Well, our office was right across the hall from the vending machine, so pretty soon we get this call saying, "You know, the vending companies noticed that they're not selling any coffee anymore." That's because we had all chipped in $25 apiece for the coffee, and Vicky was ordering these big urns, and we weren't charging anybody. So they said, "You're going to have to put up a sign and start charging for your coffee. You don't have to collect for it, but you at least have to put the sign up."

So we said, "Okay. What do we have to charge?"

They said, "Ten cents a cup."

"Okay." So we put the sign up. Well, all of these young engineers working for McDonnell Douglas wanted to come in and talk to Vicky, and they also wanted a cup of coffee, but they couldn't get a cup of coffee for free anymore, because it said ten cents, and they would feel cheap if they didn't pay their ten cents, so they started paying.

This went on for a while, and one day Vicky said to Dick and I, "What am I supposed to do with all this money?"

We said, "What money?"

She opens up her bottom desk drawer, and here's all this change and one-dollar bills.

"Hmm. Okay, the deal is that whoever is out there over the weekend," and we always had somebody out there over the weekend, "gets Friday night dinner off of the coffee fund." So we did that for a while.

Then a little later Vicky says, "What am I supposed to do with all this money?"

We said, "What money?"

And she says, "All this money," and she opens it up and shows us again, only instead of a bunch of ones and change, now we've got twenties and tens and fives.

We said, "We don't care. Just do something with it." So, we didn't pay any attention to it, and so we kept going along.

Finally we got done with the Orbital Workshop testing, and we were phasing out, and Vicky says, "What do you want me to do with all this money?"

We said, "What money, and how much?"

She says, "Well, the coffee fund money." I won't tell you how much it was, but it was a bunch. So we said, "Hmm. Why don't we rent the country club and throw a party for the test team?" So that's what we did. [Laughs]

Another one along that line was one day Dick and I were going off to a meeting, and we were—I can't remember what the meeting was about, but one of the things we were dealing with was the ventilation fans in the Orbital Workshop, and the design of the fan and the brackets, and how it was going to be installed, and how the crew was going to have to remove it for cleaning,

and replacement. We'd been trying to get some insight into the design, and we weren't having any luck at all. We couldn't get our hands on any design details.

When we were going off to this meeting, we asked Vicky to see if she could find anything out about this fan and how it was installed. That's kind of a tough question for a secretary, but we asked her anyway. "See what you can find out. See if you can't find us a drawing or something." We go off to our meeting.

We come back. Vicky has the engineer and the vellums right there, and at that point in time we figured out we'd been misusing our secretary. [Laughter] We had not been taking advantage of the asset that we had been given. So Vicky became a real part of our team from then on, and if we ever ran into any kind of an encounter that was insurmountable by the technical team, we'd send out the person who could actually find what we were looking for. Vicky would go off and show back up with an engineer or a drawing or something that was what we needed.

WRIGHT: It's good to have good help, isn't it?

NYGREN: It is. It is. It really is. But eventually we got to a point where we had a great rapport with the McDonnell Douglas guys. We had an outstanding rapport with the Marshall management guys. The Program Manager for the Orbital Workshop was a guy by the name of John Thomas, and the mockup for the Orbital Workshop was actually built and then delivered to Marshall, and the trainer was built and delivered to JSC. But the mockup was built before the trainer, so we started doing an awful lot of work at Marshall trying to get a leg up on starting the training and procedures development.

At that point in time NASA had a contract with a charter airline. They used a Lockheed Electra that flew over to Marshall and back twice a week, so we'd fly from Houston into Redstone Arsenal [Alabama]. I'll just say a good time was had by everyone on the flights. At Marshall you had a GSA [General Services Administration] car. These cars had "Marshall Space Flight Center" written across the doors. Well, there's not a lot of places in Huntsville or anyplace else in the world that you can drive a government vehicle with "Marshall Space Flight Center" and a big NASA logo on the door.

John Thomas, who was the Program Manager, had an old red pickup he'd give to me, so you could go out to dinner at night and not feel like you were abusing the government system by driving a government car someplace you weren't supposed to take it. Those Marshall guys really turned out to be good.

The head of the Orbital Workshop mockup area was a guy by the name of J.R. Thompson, and he was a hard-as-nails guy, but as straight as you could be and willing to listen. He went on to become the Deputy Administrator for the agency. Without him, we'd have been really hard pressed with the Orbital Workshop Program. He did more to help us get our part of the program going the way it needed to go than anybody I can think of. He was just absolutely phenomenal.

We started going out to Huntington Beach when they started testing the OWS [Orbital Workshop], and we had one of our guys out there whenever the spacecraft was powered up. Dick Truly would come out and work with us. We'd be tracking what they were doing on the spacecraft—what procedures they were running, what discrepants had been written, how they were dispositioning the discrepancies—we worked with Dick to see if, from his training and experience, any of the discrepancies were of any concern to the crew. We just started building

our checklist of items that we wanted to keep track of as we went through the factory checkout, making sure we understood how items were dispositioned, and if necessary, reflected in our own documentation.

Our primary goal was to make sure that the procedures and schematics and the flight data file products the crew and flight controller were going to be using were as accurate as possible. We did a lot of this by comparing the NASA generated documents with the test procedures developed by the contractor test team. We also reviewed the discrepancies that were generated during the testing to see if any of the problems were ones that might be seen during flight or if the "disposition" might change the configuration in a manner that might affect the NASA documentation. We did this mostly by sitting down with the contractor procedures writers and test personnel and discussing any discrepancies between how their procedures performed a function versus how the NASA procedure had the crew performing the same function.

Flight Operations had their own contract, generally with the prime contractor, to compare the spacecraft design with the flight documentation. Generally, they were not involved with the testing. They would look at the drawings and do the comparisons, but they didn't actually go to the next step and compare the test results against the spacecraft design. We were more the check and balances, when you actually operate the spacecraft, "does it really work the way it was intended to operate?" You'd be surprised at how many times you'd find things that were just slightly different. This is the design, but this is the as-built, and they're just slightly different.

A couple of the major things that we uncovered while we were out there, that were surprises to us as well as to a lot of other folks, was that Skylab was for us the first time that we were launching spares. We had to launch spare fans, spare filters, just about spare everything.

Well, it just dawned on us, and I think it was our guys that first thought about the fact that the spares were being launched in a different environment than the "installed" hardware. So then you have to start thinking about how do I certify all of this hardware for the launch environment for the spares? I've done it for the big picture of how we're going to actually launch the vehicle, but all of these spares haven't been tested in their launch environment, and that was going to be a huge, huge cost delta and schedule impact, to go back and do all the testing and analysis. So they came up with the concept to soft-stow as may spares as possible. Soft-stow equated to fitting the spares in cardboard cutouts.

This led to the question of what items are you supposed to keep and what are you supposed to throw away? This led to the green dot concept. The green dot. If an item had a green dot, you didn't need it. You could throw it away. Then we looked around saying, "We've got a huge amount of cardboard, and we don't have an incinerator. What are we going to do with it?" We ended up actually using the plenum area between the two propellant tanks. The circular plenum area was open, and we ended up making little bungee tie-down straps and big net bags. We stowed all of the cardboard with the green dots in the plenum mounted up against the outside wall of the spacecraft.

It was one of those things that we really hadn't thought about, because none of the previous spacecraft carried any spares. But then all of a sudden we said, "Well, we've got all these spares, and we've got them all hard mounted in these big huge blockers, and they're not anywheres at all in the same orientation or structurally mounted the same. The structural vibration that you're going to see during launch is going to be different than where it's mounted for its use location. How are we going to certify the hardware for the launch locations?"

There was so much personal [crew member specific] hardware that we needed some way to identify personal equipment and which lockers it was to be stowed in. They came up with this Snoopy decal, and they had red and blue and white Snoopy decals, and it had a little picture of a Snoopy with his helmet, like what you see for the Manned Flight Awareness [Awards, Silver Snoopy]. So each crew member's personal items (clothing, food, food trays) had a color-coded Snoopy decal.

One of the other things that we dealt with was trying to figure out how to restrain the crew members on orbit. The Oribtal Workshop floors are a triangular-grid. We ended up with a shoe that had a mating triangular grid. The design is totally different, but the concept is the same as racing bikes that have a cleat on the bottom. You step in the pedal, and it locks in place. The OWS shoe had a little triangular cleat on the bottom of it, and then you could cock it just slightly, and the shoe would lock in place. Being triangular, it was symmetrical, so you could lock in each of three directions. So, if you go into the Oribtal Workshop, the floors are all see-through, and they've got the triangular pattern.

This was something that we really struggled with in the beginning. When you're trying to do something in zero gravity, you've got to be able to restrain yourself. If you can't restrain yourself with your feet, then it takes at least one hand holding on to a handrail or something, and this becomes really inefficient. So the triangular floors and shoes were an ingenious design.

Trying to work the crew station sleep compartments and the sleep restraint were some of the things. Al Bean got involved extensively in the sleep restraint design. We must have redesigned that sleep restraint twenty times, trying to figure out how to get it to give the crew member a certain amount of mobility so he doesn't feel that he's constrained when he's sleeping.

After we started flying, I don't remember ever hearing anybody say that they had a problem with the sleep restraint, because it had a lot of flexibility built into it, bungees that you could extend and release and take off, and different zipper configurations. It took a long time to get "right," but I think it really paid off.

But I think that the design of the station actually turned out to be really good, and Bean is responsible for a lot of that. He did a lot of work for us on the sleep restraint system.

We did a lot of the early development work in the mockup at Marshall. Marshall put together a really good team of folks. We went over and started to work on our procedures and going through the timelines, trying to get the right timeline. It wasn't near as complicated as Apollo, where you have a little bitty module that you can hardly get into. The Oribtal Workshop gives you an awful lot of space that you could operate in, but it takes a lot of time to sit down and think about where you want to have certain pieces of equipment so you don't waste time going clear across the Oribtal Workshop to get one piece of equipment.

You want to have all of the equipment concentrated in one place, and then if you're going to use it in a particular location, you need some kind of a restraint device that will allow you to move the equipment to the use location and restrain all the items. You want to be able to move all of the equipment to its use location. Designing a bag that will hold all of the equipment or, if it's something like a camera system, we would actually design the locker drawer so you could pull it out, and all the items would have friction fit stowage inserts. You'd take the whole drawer with you to the use location and restrain it with Velcro, a bungee, or a snap.

You had to work through each one of the crew activities and what equipment they were going to need so you could make sure that, to the maximum extent possible, the equipment was all stowed in the same place so they didn't have to go to a number of different places to get it,

that in the use location you had some way to restrain it so they could get to it in a reasonable fashion and it didn't interfere with something else that was going on in that particular area at the same time.

We used the mockup at Marshall to do a lot of early timeline analysis. We were trying to make sure that as different events were happening, whether it was getting up in the morning and doing the personal hygiene, fixing a meal, doing the exercise routine, or running an experiment, we had the right equipment and the needed temporary restraints for the equipment available. We'd dry-run the flight experiment procedure finding all the equipment needed for the experiment, assessing whether it was efficiently stowed and if we had ways to restrain the equipment during transfer.

These exercises identified numerous changes that should be made. Following these exercises we would work with the Marshall management team on changes we felt should be made. Those changes cost money, and people wanted to know if they were really necessary. That's where guys like Bob Thompson just became invaluable, because his team was working with us. They had their team following what we did and why, helping us dry run the procedure, and through their participation they became our advocates.

WRIGHT: Were there ever any activities or experiments suggested that, after you went through the mockup or procedures, it just wasn't going to work and they had to scrap them?

NYGREN: No, none where we had to demanifest the experiment, that I remember. We had to move experiments physically around, because they interfered with other activities, and we had to change the timeline because there were times when the configurations were incompatible.

The Oribtal Workshop used two airlocks, one that was pointed towards the sun and one that was pointed towards the Earth, and they were used to hook up experiments. Some of the experiments that used the airlock were easy to hook up, and they only stuck out about a foot. There were other experiments that stuck out four or five feet into the Oribtal Workshop, and when you have something like that sticking out, there are a lot of other activities that you can't do around the airlock. When the experiments are up, you have to make sure you're not trying to perform other activities in the same locations, so you had to pay attention to the overall configuration. As it turned out, the solar airlocks ended up being used for the sail and were totally useless for running experiments during the mission.

The timeline ended up getting changed when the airlock was no longer available. As far as actually saying, "This experiment doesn't fit. We can't find a way to make it work," I don't think we had any of those.

WRIGHT: Any thoughts you'd like to share about those days from when Skylab 1 went up and you realized you had to do the parasail? How much did that change your configurations and prep work?

NYGREN: After the launch, it was a tense moment, because Skylab didn't have any power. We didn't know what problem we were dealing with. We were working on the complement of tools that might be needed if the problem was with the solar array deployment. We were considering everything that you could possibly think of at that point. We were looking at different kinds of saw designs. We were considering these big, huge bolt cutters. We had all kinds of ideas, but

they were adding weight fast, and people were frustrated because we didn't know what had caused the problem.

A number of us were in Building 5 looking at different tool designs and some prototype tools. A couple of guys came in, nicely dressed in suits, carrying a manila envelope. They came over and one of the NASA engineers with them asked us to join them. The guys took several 8x10 photos out of the envelope. The photos showed the side of the Orbital Workshop with a piece of aluminum strapping holding down the cover over one of the solar arrays. You could see exactly what was keeping the solar array from deploying. We studied the photos for a few minutes. They put the photos back in the manila envelopes and said, "You never saw those pictures and we've never been here."

We assumed the photos were from a DoD [Department of Defense] satellite. From the photos, we knew exactly what we needed. We didn't know where we were going to get the tool, but what we needed was a telescoping pole like those used to work on power lines, and we had to design a special jaw cutter. The jaw cutters were designed and built on-site. We demonstrated that the jaw cutters would cut through the aluminum strap. That was essentially it. We really didn't need a whole lot more once we knew what we were dealing with. We also had to deal with the parasail, the EVA installation, and subsequently the airlock-deployable sail.

It was intense from the time that Skylab launched until the crew launched, trying to figure out what had caused the problem and how to fix it. The crew worked with us, trying to figure out how the repair procedure could be accomplished. So we had a lot of exposure to working with the crew in that particular time frame.

It would be interesting to know what would have happened if we'd never seen those pictures, whether we'd have had the right tool or not.

WRIGHT: That's interesting. Once the Skylab was up, crew was up, how did your duties change?

NYGREN: Oh, I actually became a Flight Controller then, or a substitute Flight Controller. There were about 10,000 pieces of equipment that were launched, counting cameras, lenses, magazines, clothing, food, spare parts, etc. Using a computer, Martin, out of Denver [Colorado], had a program that helped us keep track of all of the "loose" equipment.

We had a small room over in Building 4. From there we would track the flight timeline seeing what experiments were planned to be performed. We would check the as flown timeline and from this we could determine what consumables had been used and where the loose equipment was located so we had a running inventory, in support of the Flight Activities Officer, of where all of the equipment was, what was functioning, what wasn't functioning, what had been used, what hadn't been used, and where the stuff that hadn't been used was located (stowed).

WRIGHT: What about as the next crew was approaching to launch? Were you involved with—

NYGREN: No, I wasn't. I worked the Skylab Orbital Workshop launch, and then I worked Skylab 1 with Conrad, [Paul J.] Weitz, and [Joseph P.] Kerwin. But I didn't work the subsequent Command Module launches.

WRIGHT: I know we talked about your time at Marshall. Is there much you want to talk about with your work at Kennedy with Skylab as well?

NYGREN: The kind of work that we did on the Orbital Workshop at Kennedy was similar to the work we did on the Command Modules. We looked at all of the systems procedures and we built up our complement of decals that we were going to install prior to closeout of the Orbital Workshop. It turns out that the Orbital Workshop, the actual final closeout for configuring the spacecraft, setting all the switches the way that we wanted to set them, was done by Bob Crippen and Hank [Henry W.] Hartsfield and myself. I have a picture of the three of us in our fancy little bunny suits, standing in front of the control panel in the Orbital Workshop while we were closing the Orbital Workshop out.

As we were talking over the break, the flight crew support team office was on like the thirty-ninth floor of the VAB, in one tower, and the Orbital Workshop was in another tower that was across the high bay. The way back and forth was on a catwalk that had an open-grate floor in it. If you didn't like altitudes, you didn't like that catwalk. I don't know of anybody that actually rode the elevator down and walked across and came back up, but I could see where if people were afraid of heights, that would be the solution, because the people on the floor looked like ants.

One of the things that I remember was very late in the program. McDonnell Douglas had built a toolkit that was based on all of the routine maintenance. Late in the program, we decided we needed a set of Allen wrenches. "We ought to fly up a set of Allen wrenches. We don't have anything that we need them for, but it's one of the things that ought to be in your toolbox."

I got the job of finding the set of Allen wrenches, so I'm looking at all these catalogs. You don't want to fly cadmium-plated metal in a high-oxygen environment, so I needed a set of Allen wrenches that wasn't cadmium-plated. Finally, I found a set at Sears. After work one day I drove down to Sears on Merritt Island [Florida] and found the set of wrenches and bought them for whatever it was, six dollars or something like that. I took them back out to the Cape and got some Freon and washed them down and put them in a plastic bag, sealed them up, got a little piece of gray tape and wrote their new part number that we created in real time on the grey tape. I don't remember what the part number was, but it was something we created on our Type A TPS. When we stowed the spacecraft for launch, we stowed that set of Allen wrenches in that plastic bag. I have no idea whether anybody ever opened them or not, but there at the last minute we decided we needed a set of Allen wrenches.

Other things from Skylab, let me see. [Pause; refers to notes.] I think I covered everything on my list without even looking at it.

WRIGHT: Working during Skylab, the budget and the support for the space program was starting to be decreased on the Congressional level. Did that have an impact on what you were doing?

NYGREN: Yes, it did, because Skylab was probably our first dollar-constrained program, from a NASA perspective, because during Apollo the money was available. The Marshall management that had to pay the bill for changes looked at the changes a lot harder than the previous program management in Apollo. We had to have what I would consider better justification for some of the "make better" as opposed to "make work" improvements that we really wanted. So the

Marshall guys were much more dollar-conscious than the JSC Apollo Program Managers had to be, from my perspective.

But I think that the Marshall management—and since I wasn't working their budget, I can't really speak for it—but I think that they did a good job of listening to us and supporting us on the things that we could really explain why we wanted the changes. These were not "make work," but it was "make better," that it saved time on orbit or it reduced the number of spares that we would have to take if we took this particular approach to it.

There are probably still managers at Marshall saying, "Those crazy crew guys came in with all those dumb questions and requests, and we couldn't figure out why they wanted them." But in my opinion, the Marshall management did a good job of listening to us and generally supporting us. They were a good bunch to work with.

As I said, we established a tremendous rapport with John Thomas and Bob Thompson, and they were the key guys for us. John being the Program Manager, it was his money. Bob Thompson was responsible for the Orbital Workshop crew station design. If Bob said, "Yeah, I understand why you're doing it. I'll support you," it got done. If we couldn't convince him, then we were wasting our time going to talk to John. But Bob was very supportive of what we did once he got comfortable with us. He had a great bunch of Marshall engineers working with him.

WRIGHT: You were with Skylab throughout the duration?

NYGREN: Yes. Right after it was over with, I got assigned to Apollo-Soyuz.

WRIGHT: Were most of the people you started with—did you all pretty much stay on Skylab, or were people being moved around?

NYGREN: Yes, from my group it was pretty much the same bunch of guys all the way through, including the Martin contractor team. We had about thirteen Martin guys that supported us, and almost every one of them, to the man, stayed all the way through the program. Now, some of the guys that supported us in the launch, prelaunch testing, went back to Denver and were actually working on the software program where we kept track of all the loose equipment and spares, and then some of them actually stayed in Houston and worked with us in Building 4 in our little cubicle. We had a mix in that particular arena, but as far as from when we started the Orbital Workshop testing and experiment development at the beginning of the program, almost to a man, I think those guys stayed with us all the way through.

WRIGHT: Since you've been kind enough to mention a couple of personal side notes, I thought I would ask—during the sixties was a pretty turbulent time for people of your age group and coming out of college. Were you aware of all the other issues that were going on in the midst of trying to get everything done for Apollo and then into Skylab?

NYGREN: Interestingly enough, really not. I think back a little bit about why. I don't know whether it was growing up in a small town and not being exposed to what was going on out there, and after I got to work, whether it was the work was so intense that I just wasn't paying that much attention to the news or reading newspapers, but, in all honesty, it was happening around me, and I was pretty much oblivious to it.

WRIGHT: Yes, from what you've told us, your schedules were pretty intense.

NYGREN: Oh yes, yes. You didn't have a lot of time to go do anything. I would say again on a side note, that it took a toll on my personal life. Now, I didn't end up with a divorce or anything, but the amount of time I spent with my oldest daughter was insignificant compared to what I spent with my second child, which is another daughter, and my son, because when my oldest daughter was little, I was working all the time and spent very little time with her. Wife raised her. When she started high school, I started realizing that I didn't have the rapport with her that I should have with one of my children, and so I said, "I can't let this happen."

The other kids were still young enough that I started getting involved, and I started coaching Little Dribblers teams and baseball teams and doing the things that parents do, or should do. I have established a much better rapport with the two younger kids than I had with the older one. Now, over the years I've made up some of that, but there are years in there that you never get back. There's nothing you can do about it. They are gone, and you can't do anything about it. I wouldn't do it the same way again.

It's interesting, because in today's environment, where our greatest asset is our people, and we need to make sure that they work in a safe environment, and we need to make sure that family is number one. When I'm managing young people who have that perception, and I grew up with the "you do whatever it takes to get the job done," there's a conflict there. There really is, and one has to deal with the new work ethic. I don't know if the other managers that are my age had the same struggle that I did. When I brought in new engineers right out of college, they felt the job was interesting, and the salary was enough to get me by, but my personal interests

and my family are higher priority than the space business, that was foreign to me. The space business was what it was all about when I started. You worked as long as you had to to get the job done, and frequently it was sixteen, eighteen hours a day.

For years I kept track of a log for when I was on travel, just when I left, when I came back, when I left, when I came back. Many years I was on the road 250 days a year, so I spent a lot of time on the road. But that was the job. The job was when the spacecraft was ready to start testing in the factory, you went to the factory. When you're ready to ship it, you went back to Houston while they were shipping it, and when they got the spacecraft to the Cape and they started testing, your job was at the Cape. The reason you came back to Houston was to work with the flight control team and the trainers. As soon as you got the data passed on you headed back to the Cape, because that's where the work was.

It was fascinating, and we'll get into more of it when we get into Shuttle, but I got to know most of the flight controllers, the trainers, the experiment developers, and the KSC team. I also got to know a lot of the contractors. I had a huge amount of interfaces, and that was really rewarding, because just about anything you wanted to do, you had the right ties to get it done.

WRIGHT: Well, we look forward to the next session.

NYGREN: ASTP would be the next thing, and there's some interesting sidelights to ASTP. Although the work is very similar to what I did on [Apollo] 9 and 12, there will be some personal sidelights associated with dealing with the Russians. But yes, give me a week or two to improve my memory, it would be helpful. [Laughter]

[End of interview]