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ORAL HISTORY 2 TRANSCRIPT

JOHN D. "DENNY" HOLT
INTERVIEWED BY REBECCA WRIGHT
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WRIGHT: Today is December 1, 2004. This oral history interview with Denny Holt is being conducted in Houston, Texas for the NASA Johnson Space Center Oral History Project. The interviewer is Rebecca Wright, assisted by Sandra Johnson and Jennifer Ross-Nazzal. This interview is the second session with Mr. Holt and will focus on his days with NASA after the completion of Skylab.

We'd like to start today by asking you what your duties were after Skylab and how you became involved with the Shuttle Program?

HOLT: Right after Skylab, at this time, [Christopher C.] Kraft was the Center Director, and there was a major reorganization at the center, to put the flight crew and all the flight planning and flight crew training that had been separate under [Donald K.] Deke Slayton back in the Apollo days and through Skylab. That then got merged with the flight operations, flight control function. That was always something that Kraft wanted. So he never liked the division of having the flight crews and their training to be separate from the flight controllers and their training and their preparation. So the split in the Center became one of the expertise to go implement the flight, the flight controllers and flight crews. Then they threw the airplanes in because of support elements there, and all the training activities associated were all then part of flight operations.

Then the development of the Control Center, the actual building of crew trainers, the mission profiles, and the mission planning, and all the detailed analysis was classified as a development activity. That was left under [Howard W.] Bill Tindall in the Data Systems Analysis Directorate. So you had the Flight Operations Directorate, and you had the Systems Analysis Directorate and right after it. So we were all in a new organization, and everybody that had hired into Flight Ops [Operations] in the old days spent their careers over in Building 30.

The first thing that happened was we all moved to Building 4. That was to get us closer to the crews and get us closer to the crew trainers. So we just moved our operation. So everybody moved. That was the first thing that happened after Skylab.

We had a lot of people that were affiliated with Martin Marietta [Corporation] or Ball Brothers Research [Ball Aerospace & Technologies Corporation] or the companies that were no longer going to support, that had been part of Skylab. A lot of those guys moved on, so you didn't have as much turnover as you did going from Apollo into Skylab, and there were a lot of guys that—we'd been an extended family, and it was a badgeless society. You lived with the contractors, and you sat in the same offices, and it was really—you might as well take your badges off when you walked in the door. Everybody knew who we worked for. It was Kraft and, you know, [Eugene F.] Kranz, and that was it.

The development contracts, like Singer-Link [Corporation] for the trainers, they were managed more in a product-oriented environment. We were all skills, so flight controllers were going to be flight controllers regardless of what their affiliation was.

So we had a good mix of Philco-Ford [Corporation]. McDonnell Douglas [Corporation] got the integration contract for Shuttle Program, so we had a lot of new and an influx of McDonnell Douglas that we had to deal with. They had gotten the contract based on low cost, so

they came in with a few senior middle-level guys and a whole bunch of "fresh-outs." So it was kind of interesting from the standpoint of all us who'd been fresh-outs as civil servants, had been trained by the old Philco-Ford tech reps [technical representatives], and the guys who were '37, born in 1937, since we were their slave labor.

So all of a sudden we were the five-year, six-year, seven-year employees with the experience, and now we were having to educate the next round, and this time they were McDonnell Douglas contractors. A lot of them, the way it's worked in the past out here is JSC's always been the social society that says once you got a good one, if you could, you hired him and converted him to civil service. So there was a lot of that as well. That works well at some times, doesn't work well at others. Under Mr. [James M.] Beggs, it didn't work at all, because he put down a rule that said you can't hire anybody that's been out school over two years into civil service. He didn't want you training them up as [contractors]—he wanted you to go straight to college and get them. He said, "I've already got the other ones. Why should I go buy them?" So it was a different environment back in those days. So you get some of that.

But in the days right after Skylab and in the formation of Shuttle, the Ops guys really weren't that busy. We did the Apollo-Soyuz Program, which was the 1976 stunt we did with the Russians, and it was programmed pretty much as a gap filler. It kept people fairly busy and gave them something to do while people were starting to work on Shuttle.

Kranz had justified keeping the whole team together, and Kraft wanted to keep the whole team together, so they justified maintaining a level, pretty much, across there. But there really wasn't that much work. So from those of us who were sitting down in the bowels of the system, we knew what the grand plan was, but we also knew that we had an awful lot of time on our hands compared to what we'd been used to. They probably won't like to hear that, but we filled

out our timecards just like we—but the days that you really wish you could have done something, you know, there just really weren't that many good days at work back in there. If Shuttle had been on schedule, then it wouldn't have been that way, but Shuttle was slipping.

So I did a little work back with Apollo-Soyuz, but not much. Most of the things I started working on as soon as I got over there were requirements for crew training and crew trainers. We were trying to build a training program under—[James W.] Jim Bilodeau was the Division Chief, Crew Training and Procedures. Jim had been in the Crew Procedures business. Then Carl [B.] Shelley was the Deputy. Carl had done the training job for Apollo over on the Flight Control Operations side. [Charles R.] Chuck Lewis was the Branch Chief and had come out of Flight Directors. All the guys that had been Flight Directors back there in Skylab, Kranz had to sprinkle them around and make them real managers instead of having them in staff jobs. So they all went into management jobs.

Our job then became one of trying to figure out what crew training was going to be like, trying to build a program, trying to figure out what this was going to entail. It came in two flavors, the Approach and Landing Test program, which weren't that many people who actually worked on Approach and Landing Test, especially in Operations. [Donald R.] Don Puddy was the Flight Director, and you only had one team of folks. Then you had two crews, Fred [W.] Haise, [Charles] Gordon Fullerton, and then Joe [Henry] Engle and [Richard H.] Dick Truly.

So I ended up as the Lead Simulation Instructor over in Building 5 on the crew trainer. We had the responsibilities, then, to go conduct exercises with the crews for the daunting challenge of flying from 22,000 feet all the way to the ground and getting hauled in back of a [Boeing] 747. It was interesting. Simulators are really complicated devices, and especially the Shuttle simulator was kind of a departure from the way they'd always developed simulators,

because we took the Shuttle flight computer and loaded the flight code in there. So you actually trained with what you were going to fly with, the difference being that you really weren't wiggling rudders and speed brakes, so all that had to be simulated. So the simulator itself was a very, very complicated beast, a great big visual scene board, about maybe forty feet long and twenty feet wide, down to where it was—you could actually see sagebrush out at [NASA] Dryden [Flight Research Center, Edwards, California]. So it was a very, very complicated system, a high-resolution system built by Singer.

So we'd all gone through the procurement, and Singer won that, and then Singer would eventually be the contractor on the Shuttle Mission Simulator. NASA was always—Singer-Link guys were mostly from Binghamton, New York. It was kind of an interesting clash of cultures. They did it their way, much to the chagrin of pretty much everybody that managed them from down here. And it worked. It just wasn't exactly the way we'd have liked to have seen it done, and they really didn't care. So we went through quite a few rounds with them over their approach. It was kind of like everybody worked together against each other for a common cause, you know, that type of thing. So it was interesting times back then.

You weren't quite sure, when you saw things happening to where the simulator wasn't acting properly, you weren't quite sure whether that was flight code or whether that was a simulation problem. Naturally you had IBM [International Business Machine] tech [technical] support there, and everything they saw obviously was a simulation problem. Everything Singer-Link saw was "Probably that could be [flight] software." So there was an awful lot of discussion that we had. It was really a proving ground for a lot of the way the flight code ran.

The first closed-loop demonstration of the flight code with a manual input was in the crew trainer, which was quite a departure from what you'd had in previous days. Usually you'd

have a big iron bird somewhere, and you'd go run all your training. In this case, we learned an awful lot about the flight code just by osmosis. It was interesting times.

When we bought the simulator—probably the classic of how interesting they could get, Singer-Link—the day they bought it off, we were in Building 5, and they just had been throwing out the Lunar Module simulator to make a spot for this. It was a big motion-based simulator. It is today's motion-base [of the Shuttle Mission Simulator]. Okay, so we had the start of that. But it was running on a different computer platform altogether.

The day they sold that simulator was in September, hotter than blue blazes outside. It was about 32 degrees inside. I think I've never been in that building when it was that cold. I know Singer-Link had it down as cold as they could get it just to make sure everything that had electronics in it was not going to overheat. They were bound and determined they were going to sell that simulator.

We had the crew. Fred Haise and Gordon Fullerton were flying. As soon as the crew would separate from the 747, get ready to fly straight in, then it would take only about maybe one or two seconds, and all of a sudden, this monster simulator is up here going just side to side, and the hydraulics in the big legs are going up and down, and it's hissing and moaning and everything, and it's slamming against the stops. Then it would settle in when it finally violated its limits. We did this for about an hour and a half. Finally Fred Haise says, "I just think I've had enough of this." So we all got in the conference room. Fred says, "Look, guys, this Shuttle is not going to fly like this."

They [Singer-Link] said, "Well, Al Ragsdale," who was one of the simulation guys, "Al's figured out how to fly this."

So they go back out and get in the simulator. I was listening in to the intercom. So at separation, Al says, "See now, right here, Fred. See now, when the needle goes all the way to the left, you stomp on the wrong rudder pedal and it'll re-center it. And if you just kind of hang on, it'll fly it on in here."

They landed, and Fred says, "Al, airplanes don't fly like that."

He says, "Yeah, I know." [Laughs]

So we go back in there, and he says, "Okay. You guys need to go to work on this a little more."

It turned out that the answer was fairly simple. The rate gyros in the Orbiter are in the back end of the vehicle. The accelerometers are in the front of the vehicle. The guy that worked on the rate gyros and accelerometers, the Singer-Link engineer, was doing both of them at the same time. Unfortunately, he coded them such that the accelerometers ended up in the back.

Well, anytime you put an input like this, the vehicle would sense it, and it was sensing it the wrong way. It was adding to it. So the next thing you know, this thing's going back and forth, and it's making—it was really interesting. So we watched that pinball machine for a year over there.

So we had two teams of simulator instructors, myself and Olan [J.] Bertrand, a team of two, and Jerry [W.] Mill and [Robert L.] Bob Hahne, a team of two. We split up and went through with—did four-hour blocks with Haise and Fullerton and Dick and Joe just all the way through the program. Then we'd do some integrated training with Don Puddy's flight control team. They were limited only by the fact that you didn't get all the data down; you only got one string of data out of the system. So when we did integrated training, the crew actually had more data on the board than the ground did. So it was kind of more of a—they did the ground control

approach for winds and stuff like this, but it wasn't really a big—the training exercises were more intense for the crew than they were for the combined team, which is somewhat different than what you get into in full-up Shuttle.

The classic crews were good enough to where Dick Truly and Joe Engle were also known as the ALT [Approach and Landing Test] a cappella choir for their rendition of "Fine Time to Leave Me, Lucille," just probably one of the worst songs that—their rendition was poor.

WRIGHT: They entertained the troops, huh?

HOLT: They entertained the troops, yes. We spent a lot of time being down. It's all in the simulators. They'd go down, they'd come back up. So we learned a lot about patience in that environment.

But that was our first real introduction to what Shuttle was going to be like and how complicated it was, because you had all the redundant systems. When you think about it, the Shuttle failures that we've had have really been failures of the structure and something very large and structural failures. Your training that you do for the crews is really a training of the timeline, procedures, malfunctions, all of the things that can go wrong in the systems, things that you can do something about. If the wing falls off, there's just nothing you can do about that. So we had built training flows and went through and laid down a program that's pretty much the structure that they have today, although they're much more organized than we were. We were still trying to figure out exactly what you would do.

So at the end of ALT we took all the crews through, and everybody got to play, got their stick time, and everybody got their chance. During the landing for the last ALT flight, there was a PIO, problem-induced oscillation, so you got a little of that.

Everybody that showed up was convinced that they understood it better than anybody else, and they all wanted to give it a try, only to find out that anything they did within five feet of the runway, whether you tried to push the stick down, pull the stick back, anything you did ended up with you bounced, and it was a bad idea. It was pretty much, with this vehicle, when you're getting ready to land, you just let it land. There's not much you can do except just let it mush on in there and do its thing. I remember every one of them came over, and we had to go through that discussion with everybody. You just let them go do their thing. Then when they got through, they said, "That didn't work, did it?"

I said "No. Nobody else made it work either, but thanks for trying."

WRIGHT: Was there a little competition between the crews?

HOLT: Oh, there's always competition. Yes, they're all that way. Actually, it's not just the crews. Competition's what fueled the whole engine for Apollo. The comment I made a while ago about everybody working against each other for a common cause, there were days when you swore up and down that there were people who were out to get you. But teams had natural competitions. Flight directors all were running for Center Director. So everybody was competing with everybody else. But the kind of competition was to be the best. It rarely was mean-spirited. It was almost always one-upmanship and "We're smarter than you are." In fact, I'm convinced, after spending the time I did in simulation, that there were guys who worked here

just to be able to go do sims [simulations] and show that they were smarter than everybody else, because they're natural problem solvers and they loved it.

WRIGHT: Was technology advancements affecting your job as far as technology changing?

HOLT: No, not really. Start of Skylab, we still didn't have a word processor. Memos were typewritten, and we wore out Xerox machines on a daily basis. It was probably 1983 or so before we got the first word processors in there, and they were the Xerox system that was right before the Xerox Wordstar. That was the first time we ever got—that was probably 1984.

So, no, we were still in the Dark Ages relative to that. The computers that were running the simulators were. We were seeing the first minicomputers at that time, which were Interdata [832s], all running then off of a central [Univac] host.

When we went to the SMS, the Shuttle Mission Simulator, then that was the first big technological leap, because you had a digital video system for crew visual. There were all kinds of arguments over whether that would be acceptable or not. Well, today's video games pretty much show that that's possible. Today's video games are so far ahead of—we might as well have been playing Pong compared to what they've got today. Crews would come flying in, and depending on how busy the computer was, buildings could come and go out of the field of view. That was kind of disconcerting sometimes.

But that was a big effort, and we had lots and lots of development problems with the simulators. By the time I did the entry training flow for Shuttle, Frank Hughes did the ascent, Anne [L.] Accola did the orbit, and we laid out then what we thought—the numbers of hours it

would take in order to do this. For the first flight, we figured it was about 500 hours of crew training plus sims, the integrated training with the flight controllers.

I can remember the day that it was finally—[Melvin L.] Mel Richmond and I put together this package for George [W. S.] Abbey and Gene Kranz, who were Director and Deputy Director of Flight Operations. I'd been through the fourteenth dry run of this package, and Carl Shelley finally says, "Okay now, take your conclusions chart and put it on the front."

I said, "No. You've got to be kidding me." I said, "Look, I've made enough pitches to Kranz in my lifetime, I know that the conclusions have to be on the back."

He said, "Yeah, but George is going to be there." He says, "You need to put it on in both places."

I told Carl, I said, "No, I just don't think that's going to work." So I did it anyhow.

Carl's six-five and weighs about 260 pounds, and was my boss, so I did pretty much what he told me to do.

So in the meeting, we put the second chart up, and it says "Here's how many hours for the first flight, and here's how many for STS-2." George says, "Well, I don't understand your STS-2 numbers because they're *x*."

I said, "Well, no. If you go back to chart 400," wherever it was in this monster package—and we went though a couple of steps.

George says, "Okay. There's just one more question." Then he says, "Okay. That looks about right."

Of course, Gene's sitting there, and Gene says, "What do you mean it looks about right?" He says, "We're going to go through this whole package." [Laughs] And we did.

So George says, "Well, when you guys have satisfied Gene, y'all can go," and we knew it was going to be awhile. So about 400 action items later, we got down to the conclusions chart, and Gene read the conclusions, agreed with the conclusions, and then handed us our action items and told us, "Here's what you can do for the next six months." So it was interesting.

But we really were struggling with the ideas of a program for training, because all the way through Apollo, each flight had been unique. Each vehicle was new. You had no reuse. You weren't trying to run an airline-type operation or a military-type operation.

We had talked to Boeing, and they had brought in the Boeing head of training from Seattle [Washington]. We had a good four-hour discussion with him. He pretty much laid out how they went about their business, and we showed him what we had in mind. Along about three hours into our four hours, we started probing. One of the questions was, "Well, just how do you deal with change?"

He said, "Well, changes are not a problem." He says, "If we get a change every couple of months, we're able to keep that up."

I said, "Okay. So how do you handle a thing that says you get a change a day?"

He said, "Well, you guys don't have an operations program. You're still R&D [research and development]." And we really were.

So we struggled with the trappings of the program and trying to put the wrapper on it at the same time, when we were just scrambling to be able to keep up with the development activity in the Shuttle. Every time you dropped a new version of flight software, we had a big checkout activity we had to go through. Every time Singer-Link updated the configuration in the simulator, it was like something that was working didn't work now. You had to go back and find all those. So we were in this constant cycle of trying to get it all together.

For the first Shuttle flight, I took over as the First Simulation Supervisor, so I was over setting up the integrated training runs, which was the training with the flight control team in Building 30 and the crew running over in Building 5 in the simulators. We were doing about right at thirty hours a week, thirty-two hours a week, of training. The other eight hours of that week we wrote scripts. We had three teams of flight controllers—ascent, orbit, and entry—and I had one team of simulation guys, and we did all three phases. So literally, all we did was write scripts.

The amount of time just getting the two buildings [SMS and the Mission Control Center] to play with each other was kind of a monumental-type thing, too, because the simulator had been set up for crew training and it really wasn't ideal for ground controller training. All the parameters that came across to Building 30 didn't look right. So the first thing we did—we did about a month and gave up—we did a big exercise to go through methodically and have the flight controllers and the training guys go through every parameter and document exactly what the problems were and look at all the systems.

It was beneficial from the standpoint of the guys who were working in the flight control world who were following the development of Shuttle. They had to take that knowledge and plow it back into the simulator at a level that says, this simulator is not doing as well as it needs to. Quite frankly, if it was not needed by the flight computer to run, then it wasn't that big of a deal. So it's the kind of thing that says, when it rises to a level on your priority list where it suddenly becomes an irritant, then you go work on it. That's literally what we did. We just went around stomping on tall poles trying to get ready.

WRIGHT: How did the slip in schedule affect what you were doing?

HOLT: Well, we'd have never made it if—literally, the slip in schedule just changed everything. When they updated flight software—flight software was behind. Certain systems were behind. So every time they updated, we updated, and we just tried to keep up to see what the effects would be.

There were a few really very good decisions made. One of them was to keep the one flight plan for the entire period there for the first flight, so we trained with one flight plan. Then it changed about two months before we flew, because by then they had to pick up all the things that they knew had changed to where you really couldn't operate. This wasn't the optimum flight. There were only three days for STS-1. You just were able to kind of get into a rhythm, and you were able to then work through it.

But the teams—literally, guys walked in, a lot of them hadn't been in the Control Center since Apollo, and some of them hadn't ever been in the Control Center. About the time we started integrated training in 1979, a lot of those guys didn't work Skylab, so it was 1972 since they had seen their last flight. So even though you had guys that had a lot of experience, you had to start building the teams all over again. And you had three teams, and the teams were large. You made sure that you had enough people there to go look at all the systems. The idea was that as soon as we started flying fifty-two flights a year, of course, on the Shuttle, you would cut it back to where we only had four people in the Control Center at all times, because the crew was doing all the work.

That operations concept was so far out of—it just never had any ground in reality. It was part of the sales pitch for Shuttle, and the problem was that your staffing levels and your budgets were all based on that. So, retracting a lot of that stuff was painful throughout the system, and

most of us who then moved into management positions had to deal with the pain from a standpoint of saying, "That ain't gonna work." So we spent a lot of time building rationale for why you had to have more people and why you had to do certain things and why you needed five teams and that type of stuff.

We ran a bunch of training sims. We ran our first long simulations that we did, where we brought in the extended team. The engineering support team at Rockwell [International Corporation] had the Mission Evaluation Room. JSC Engineering felt that all the pieces of the puzzle are going to be there when you fly. We were going to do our first thirty-hour exercise. The simulator wasn't good at staying up for more than maybe an hour or four hours at a lick, and we were going to start up and do thirty overnight, so it was kind of touch-and-go. We brought up the first day, and Neil [B.] Hutchinson comes in, who's ascent team. It's seven o'clock in the morning, and I'm back in my cubbyhole with my team, and we get a call from over in the simulators. They said, "We're down."

I asked, "When do you think you're going to be back up?"

The guy said, "Well, not real sure. It looks like maybe we had the emergency stop button pushed."

My experience with emergency stop buttons, from my days in Building 5, was that you were lucky to get back up the next day, much less that day. So I called Neil and said, "Neil, you go ahead and dismiss your team. We're going to try this tomorrow."

I got the usual, "What?"

So pretty much I said, "I'm not even going to attempt it."

I got a call from George Abbey who was over in Building 5, and George says, "What are you doing?"

I said, "I turned it off."

George says, "Well, they're telling me over here they'll be up in an hour."

I said, "Well, get me twenty dollars of that."

Somewhere around four-thirty, five o'clock in the afternoon, they finally got the computer to where it would come up and talk to itself, much less try to run a simulation, and the next morning we were able to get going. At some point of time in there, we went up and down a few times, but we actually, I think, managed to crank out about twenty-two consecutive hours of running there at one lick through there.

So it was the kind of thing to where you got—simulators are always very interesting devices. In the sim world, you always got accused of just letting the simulator spit out whatever freebies that it could do and whatever failures it dreamed up on its own and then trying to react to them.

To an extent, that was true. You showed up with your script—I know on one exercise we were going to do fifty-six hours. We'd been running for about a year, and I was taking some heat from the flight directors, especially Hutchinson, about not having objectives written for the training exercises. So we started the sim, and about an hour and a half into the simulation, one of the [flight] computer strings in the simulator just suddenly decided that it didn't want to participate anymore. So we took our whole script and just chucked it and had to start all over again rewriting the script. Between Anne Accola and I, we had two teams by now, so we just kind of survived this thing.

I was on the hook to go debrief the flight control team with the script after the sim, on the day after. So I took what happened and built a case around that and showed up and briefed them

with exactly what happened and the objectives for every one of them. As I walked out of there, Neil Hutchinson said, "I don't believe you did that." [Laughs]

I said, "Well I can't understand why you'd say that, Neil."

He said, "Because Anne's already told me that you're over there inventing the case that goes with the things that happened this time."

I said, "Well, she ratted on me." [Laughs]

We were able to react, just to take whatever was there and turn it into a fifty-six-hour training run. You had the whole team up and running. It was like, you're only going to get this opportunity every so often, and you'd better find a way to make the most of it.

WRIGHT: When you sat to write scripts, what were some of the components that you were looking for to build into those scripts?

HOLT: Like I mentioned, the Orbiter is such an integrated vehicle, and it all has to come through—the computer controls an awful lot, and there are four individual computers here and a voting scheme. So it's the kind of thing that says, when you want redundancy, you go—let's say we have three IMUs [inertial measurement units] for platform alignments, and we have four sets of rate gyros, we have four independent actuators for each—we have ports to where you can actuate, drive the [aero] surfaces, and the jets are then sprinkled around through the computer strings so that you don't want to lose all the capability with one failure. Then you bring it all in and you put four computers together. Each computer then has a primary and a backup, and they have a big voting scheme.

What we found in the sim days—and of course we'd known it from approach and landing tests—was that if you could just lob a failure in between the responsibilities of two flight controllers, then you could just stand there and watch them jump back at first till somebody finally figured out whose responsibility it was. So for about the first six months of training, literally it was like shooting ducks in a barrel. You could just throw a failure in between two guys and just see which one of them was going to pick it up and run with it first.

The flight directors, during debriefings—the debriefings were pretty brutal. The system has always been hard on itself. Nobody gets away with anything. So if you didn't handle it very well, if the team didn't debrief it that way, then the simulation supervisor was obligated to go in and say, "You guys didn't handle that very well. You missed it flat out here here, here, and here, and this thing started on this time, and you didn't find till over there." So it's a pretty intense-type operation.

So after about six months, you started to see procedures coming together. Rules were written, responsibilities were then aligned, and the team formation came through. You had your entry and ascent. They came together. The orbit was a little slower just because we didn't train them as much. A lot of training was ascent and orbit. God, we must have failed four thousand engines in that period of time, and, literally, there's a lot of ways to do it. So we found as many as we could. You find as many paths as you can to mask failures to see if you can get people to call critical—to shut something down based on bad data.

It's a pretty tough environment, and you want to make sure that when the—but literally, when you go back to Apollo 11, the computer malfunction and the light that was on the Moon, that had been simulated. So [Stephen G.] Steve Bales and [John R.] Jack Garman had seen that failure before in a sim. [Richard H.] Dick Koos had put a case together, and they came up with

that. So when they saw it, when the chips were down, they were able to say, "Keep going." Other than that, we probably wouldn't have landed on the Moon.

WRIGHT: Based on all the training, the simulations, and all the processes that you were involved with during that time period, what were your thoughts about sending a manned mission on this new spacecraft compared to doing unmanned missions that you had been witness to before?

HOLT: We really hadn't done that many unmanned missions. The biggest single concern you had, as I got out of—let's see. I was the simulation supervisor up until 1980, and then I took over the Propulsion Section down in the Systems Division. There, literally, I went from training people to being responsible for one of the disciplines in OMS [Orbital Maneuvering System] and RCS [Reaction Control System] procedures. They were behind when I got there. But by then, when I got down there, my concern more at that time was, there's an awful lot of work to go, and there's an awful lot of fundamental-type things that hadn't been formed.

The thing that scared us all was the engines. They were still blowing engines up over on test stands over in Mississippi. In fact, [Richard H.] Dick Kohrs finally made them stop testing engines for the last three months prior to STS-1, just so we didn't have to react to another blow up an engine then go figure out why it didn't make any difference for what we had sitting on the pad.

I think probably the one most vivid memory I have of STS-1 is from watching it on TV, because I was back in the SPAN [spacecraft analysis] area in the Control Center on the next shift, but watching the three main engines going downrange, going upside down, actually, and I watched those three globes as long as you could watch them, with the hope that they never were

going to go out. We were very concerned that the engines were the weak link and that if an engine failed, no telling how it would fail, because you'd seen failures on the test stands of engines to where they had a slow scan update and one scan it was there and the next scan it was a molten pile of rubble.

Engines don't fail gracefully. When you're pumping, I think it was, 17,000 gallons a second through a seventeen-inch line, you can't even shut the valves immediately. You have to slow the flow down with pre-valves so that you can actually shut the engine off. If you shut it real fast, it'll just take all the—right on downstream with it.

We knew the engines were high-tech. The engines were unproven. The tiles were always going to be a concern just because they were the other departure from what we'd done in the past, and you knew they were a critical system. Other than that, SRBs [Solid Rocket Boosters] honestly didn't concern us as much, because there really wasn't much that you could do about them. There was no way to throttle an SRB. There was no way to turn one off. There was nothing you could—if the SRBs blew, you just blew. Pretty much everybody knew that.

Of course, on *Challenger* [STS-51-L] everybody found out just how much you couldn't do. We had procedures in place to where crews could have theoretically separated, but it would have peeled you like a banana and put you right back into—the Orbiter wasn't going to survive. It was the kind of thing that says, okay, if you had a really good day, after you had a bad day, maybe this would work, but pretty much nobody expected it to survive.

So what we had then in the early Shuttle days, going from the simulations to getting in and being down into the systems preparation, and I told you we had, like, one flight plan we ran for all this period of time, and we wanted to get all the procedures right on that plan before we started looking at the next thing. We put all our energies into the first flight. We had virtually

nothing going into the next flight. Tommy [W.] Holloway was running flight techniques for launch at that time, ascent, and we had tons of issues over just what would you do under certain situations. You had to be able to get it down to something—launch only lasts nine minutes, so you had to get it down to something that you could deal with and that the crew could do off of a cue card, because if you're under 3 Gs [gravity], lifting your arm and touching a switch, in a simulator you can reach up to do it, but if you take your arm and you put a thirty-pound weight on it and try to figure out that you're on the right switch and you're hitting it while you're doing this, then you had to be convinced that the procedures that you were doing were going to buy you something and that since the vehicle was so integrated and so wired together, some of the steps you took based on one failure were to keep the next failure from being catastrophic.

So you had reconfigurations you did, and you wanted to be very careful on those. The flight techniques activity that Tommy ran was probably the most intense set of rules and procedures that we got into. And we had arguments. We had procedures for what we would do under certain conditions with forward RCS, which was part of my responsibility. Rockwell International sent a letter to Aaron Cohen and the Orbiter Project objecting to our procedures that we were using under certain leak conditions, convinced that we might—they were pretty much telling us that we were on our own if we used those procedures, that they didn't have enough data to stand behind them. It was pretty much a contract-scope-type discussion. They knew there wasn't anything else we could do either, but corporately, they didn't like the procedures.

I talked to Sy Rubenstein [Vice President and Program Manager, Space Shuttle Development, Rockwell International] years later, and Sy told me, he said, "Yeah, well, we knew there wasn't anything else you could do, but we were obligated to tell you that we weren't sure what would happen if you pulled it off."

So we had a lot of those types of discussions, and I think, just from the perspective of the difference in today's world and then, literally the whole Center worked on Shuttle. So when you look at other programs as they've come down the pike, and I know, like in [International Space] Station when people tried to compare budgets and levels of effort that you had working on different programs, everybody worked on Shuttle. So the whole institution was aligned to support the program. There was not that much wasted effort out here, because there wasn't anything else on the horizon, so we were going to do Shuttle, and we were going to get it all done right. So anything that the Center could do was going to be done that way.

John [F.] Yardley, who was the Associate Administrator for Space Flight, when the schedule problems were just to the point where they almost couldn't deal with them anymore and slips were on us all the time, he made the Center Directors, Kraft and [William R.] Bill Lucas [NASA Marshall Space Flight Center, Huntsville, Alabama] and Kurt [H.] Debus in Florida [NASA Kennedy Space Center], responsible for the schedule. So it was the thing that said, "There will be no slips, unless you guys can tell me that there's a real good reason for it." It was no longer a [dat-for-day]—and I know the day that it came home to us was—we had a routine. Gene Kranz had a weekly session where we'd go through systems issues with Gene, and anything that was then scheduled for a Program or Project Control Board to be dispositioned, we'd run those issues past the management and within MOD [Mission Operations Directorate].

We had some valves in the forward RCS, and, like anything else, once you get into it, you realize that the valve you bought, you wish you hadn't bought. The valves were big ball-valves, and they had steel bumpers at the end where they ended traveling, and they had nylon gears. Now, most people would rather have nylon bumpers and steel gears, but these had a failure-mode to where—at the Cape [Canaveral, Kennedy Space Center, Florida], they had

actually chewed them up in some testing down there. So they stopped working. The gears just stripped.

So the answer was—the right answer was to go pull the forward RCS module out of the Orbiter, which was supposed to take five days. That was Rockwell's and the Cape's first input. It was going to take five days. Well, they didn't want to take a five-day hit. But we were talking to Gene, and one of my guys was briefing the issue, and he put it up. So the answer is, you need to pull the forward RCS. And Gene says, "Why?"

And I thought to myself, "Now, that's not the answer I was expecting." I looked at him, and I said, "Did you just ask me why we wouldn't want to fly in the situation we're in?"

He says, "Right."

I said, "I don't think that was a rhetorical question."

And he says, "You got it."

I said, "Okay."

We had a simulation that started, one of our long fifty-six-hour sims. We had Rockwell International re-engineering and rewiring the Orbiter, sending us things on console, faxing them in all night long. Then we had to go through and look at all of the failure modes of everything that they were wanting to do to bypass these two valves that had the failure. Finally we had to show up in Aaron Cohen's office. He was running the Orbiter Project. It was the Director of Engineering and [Clifford E.] Cliff Charlesworth sitting on a couch. There was this little team, and we're all standing around. Gary Cohen and Ron [D.] Dittemore had done—Ron had finally gone through and figured out all of the things that the software didn't like about the way Rockwell had wired it together. So we spit that out, and it took about thirty minutes. When it was over with, Cohen says, "Well, I think we've got to go pull it."

Charlesworth says, "I'll go tell Kraft." It was like, "Okay."

So I know the Subsystem Manager, [Donald R.] Don Blevins—Don and I had gone to college together back in Tennessee, and Don had decided that he was going to have them do some other work while they were in there. He came in the next morning, since he knew he had five days. They'd already pulled it and put it back in. [Laughs] They weren't going to give anybody another shot at this thing down at the Cape. They had figured out how to take four and a half days out of the flow. They had that thing out of there, had those valves replaced, had them back in the bird and zipped back up before anybody could say, "Oh, by the way, while you're in there—."

So from that point on, it was like everything was dead serious. There's no wasted motion between now and then. You have to get your procedures together, you have to be right, you have to—it was like all of a sudden, the whole system reacted to this thing that says, we're going to go do it finally, and it's time. So there's no slack."

WRIGHT: Before we take the next step, let's change the tapes out for just a second. We'll take a quick break.

[pause]

WRIGHT: That seemed to be the event where people started taking things serious.

HOLT: It was right before STS-1. About that last six months to a year, you really knew you had to get it together. Also, it was at that time when the day of reckoning on all of the promises that

had been made everywhere. The system has always kept very good records on—when you made a decision, the programs and the projects are paid to make sure that they know—for example, that says, "We accepted risk on this particular item because there were going to be procedures put in place to do *x*. Okay. Well, all of a sudden, people started asking where *x* was. And it had been a lot of years, so they had very good records. At the same time when we were trying to train, putting people in the Control Center on a daily basis, trying to support whatever activities were going on in the design, the program's intensity level was up over there in the program world, the intensity level was up in the projects. It was always somebody wanted an evaluation on some change. There was just a lot of activity level all of a sudden. At the same time, we had to go through and document where in all of our procedures all of these operational workarounds that had been signed up to over the years, where they were all documented; flight rules, procedures, whatever.

So that was all part of being able to do a certification flight readiness out of—MOD's part of that. So it just kind of was part of the snowball. You just tried to keep running before it ran over you, because it was definitely coming.

The day we flew STS-1, the flight was almost flawless. It literally was just the kind of thing to where you couldn't imagine that it would have gone any better. Start to finish, there were just really almost no problems.

Then we got the vehicle back, and they did some of the inspections. My favorite was the candy wrapper that they finally figured out was in a propellant line. The stuff had lodged itself in an OMS engine. Going back and looking at it, there was this minuscule little blip in the chamber pressure on the engine while it was running. It was still running fine, but you could tell that on one of the engines it just took a little drop, and that little drop was a foreign substance

that had gotten lodged. Upon further examination and over a period of time, they finally figured out it was probably a candy wrapper that somebody had thrown in there at some point of time, God knows when. It just gummed—there were little things like that.

At launch on the first flight, the pressure wave rebound off of the engines was enough to where, if you look at the Orbiter, it always kind of does this [gestures indicating a slight leaning off vertical], and then it comes back in alignment and takes off. That's called "twang." They've got a term for everything, and that's not even an acronym. So it comes back and it takes off. The pressure wave had actually bounced off the bottom of the flame bucket and sent a shockwave back through the Orbiter, and we found a shock-absorber strut on the forward RCS tank. The same tank that we had this discussion with Rockwell over whether or not they liked our leak procedures or not, had kinked. So it took enough of a ding there to where there were forces that were above the forces that the strut would take, but the tank held. Now, if you notice, they start this big water deluge well before the engines ignite. That was the change for that, to try to make sure that you dampen that force. If you've been to the Cape for a launch, you see that big ball of smoke, the steam that goes out to the sides. Well, that's the steam that's caused by the evaporation of that water. Those were the things, after you got it back, you knew that you'd kind of gotten lucky on a couple of things.

The next flight, we had an APU [Auxiliary Power Unit]. Again, you're in the early days, Engle, Truly, and the crew on the pad. We bring up an APU, and there's something that's not quite right in the APU. We were back here in Houston, and the first thing you heard was from the guy at the Cape, and he says, "I got such-and-such on the APU. I recommend we go." It was almost like he never even bothered stopping.

George [F.] Page, who was the Launch Director at the time, says, "Now, wait a minute." So he called back to—Hutchinson was the Flight Director, and they had some conversation, "Do you guys have any explanation for this?" In the meantime, the APUs are running. They're a consumable, so they burn off hydrazine, and they're running and they're running. They talk for a couple of minutes, and finally George says, "Well," he says, "what do you think, Neil?" or pretty much, not quite in those words. They were still dealing with whether or not—and Kraft came on and says, "Well I think we ought to wait until tomorrow."

George Page says, "Okay. Let's shut this down."

All they wanted was somebody to say—see, you take the old guys who'd been there, says, "There's no reason to have to go fly today." Everybody else is still out there thinking they'd go make it work.

Chris just kind of came over the top and said, "No, I don't think so."

I understand he and Mr. Beggs had quite a few conversations over the roles of Center Directors and all that. We were getting ready to go into the brave new world of NASA, and Center Directors and Administrators always kind of had this pull and tug. It's traditional. It's probably going to always be that way. But at that point you started realizing that they went off, they looked at the APUs, they came back and said, "Okay, we'll go ahead and fly."

Then we had an APU go out during flight. It was one of the APUs that they had rebuilt. They had another rebuilt APU on board, and they were worried that maybe we had a generic failure. We actually terminated that flight and brought it down early. That was a real scramble, because the two-man crew in the Orbiter really are busy. I know Dick and Joe were extremely busy getting everything buttoned up and getting out of orbit.

In today's world we wouldn't ever try to come down on the second day. We would always go to the third. But at that time you didn't have crew rest, you didn't have all those settling time things built in, so that's part of what you did in the early days.

You just always had in the back of your mind that—every flight was an R&D flight. The one we landed out in Albuquerque [New Mexico], during an approach and landing, we were doing a guidance demonstration on that flight. We were within seconds of touching down before the gear finally got down. Going back and thinking about them after it's over with, it's the kind of thing that says, man, we were operating awfully close to the margins. But at the same time, we had the team, probably, at that time, that had a greater depth of appreciation for what the system was capable of than at any other time, because they'd been immersed, and the Rockwell team was still immersed, and JSC Engineering. So the whole team had been through the war to get it ready to fly and had probably a good understanding of what it could do.

In today's world, now, we've got people sitting in the Control Center who probably were not born when we flew the first Shuttle flight. So that's the kind of—when you're looking for perspective, you know, in 1969 we landed on the Moon. There's a heck of a lot of people around that weren't alive in 1969.

WRIGHT: For the third Shuttle flight, you were serving as the Chief of the Guidance Propulsion Systems Branch. You had changed jobs. Tell us how that job was different from the previous one you had.

HOLT: We had three sections. The Prop [Propulsion] Section had the OMS and RCS. They had the on-orbit maneuvering system and the entry ascent control. But the Branch had

responsibilities for the main engines and the SRB systems, which were the hydraulics, since once you light the fuse you're on your way. Then all of the guidance and navigation and control systems as well, the accelerometers and platform and the hand controllers, displays for the crew. So there's that whole set of systems, then, that flew, that were responsible for flying the vehicle, and we had three sections, then, to do that.

The engines were particularly—[John A.] Jack Kamman was the section head there, and then Jack came into the branch after I did. He had worked—Marshall was responsible for the engines, and their contractor then was Rocketdyne. We were implementing procedures that had been hammered out with Rocketdyne and with Marshall. And that had been a big argument. On Apollo, Marshall had actually had a branch of people who were Marshall Space Flight Center employees [in the Flight Control Division], who were responsible for the booster. On this vehicle, since the engines were part of the Orbiter, the tankage, you know, is just—the argument, and it had been a fairly substantial argument—we had to operate it all as one vehicle, and that section then would be JSC employees instead of Marshall employees. That seemed to have worked out pretty well.

You ended up with some groups that were fairly insular, because once the engines shot, they were gone, and you didn't do that anymore. Everybody else worked the whole mission. So, nine minutes into it, they wrote their post-mission report. So it was a little different.

In the GNC [Guidance, Navigation, and Control] world, I think the biggest single problem in that time frame was we'd all honed our edge on flying *Columbia*, and then all of a sudden, here comes flight five, and it's *Challenger*. I can remember the first time somebody walked into my office and said, "They've changed such-and-such." I can't remember whether it was some system. "And all the parameters are different." They were rattling on all this stuff.

So I said, "Maybe we ought to sit down and talk about this."

So we sat down. Pretty much it came down—I said, "Well why did they change this?"

He says, "Well, they're flying another vehicle."

I said, "Well, you know we're going to fly another one after this, so we'd better learn how to do this." [Laughs]

So, literally, the next step was, just about the time you caught your breath from flying the first Shuttle flights and congratulating yourself on being able to do them, you had a new vehicle. It was like, now, "This vehicle doesn't look exactly like that vehicle, but in simulations, it doesn't look too much different. Now what do we have to go be prepared for?"

And the vehicles had some changes to them. Obviously *Columbia* was the first vehicle, and it was always heavier and it always had more instrumentation, it always had more stuff in it. *Challenger* and each vehicle successively either had some system or minor changes to them, and the crews could sure tell you which ones were different. The guys at the Cape that processed them, they all had personalities, so you had to learn to deal with the change.

At that time is when it really set in that the process was the only way you were going to survive, that standardizing products, standardizing different things to where you always knew what template you were on. The initial work was started up by IBM and the guys doing flight software to try to go pull together all of the dependencies and the critical path for every flight, as to what inputs had to be due at what time to make what product to deliver to the trainers, to deliver to the test rigs, to deliver to the Control Center. So at that point in time it started sinking in on everybody just how much all that free software was really going to cost you. It was always a lot easier to change out hardware than it was to change out software, because software required

you to then go back and revalidate. The hardware, a lot of times all you had to do was turn it on to see if it would take power.

So that was the next thing you learned, that Shuttle wasn't going to fly fifty-two times a year. It also wasn't going to be real easy to turn it around, and it wasn't going to be real easy to make changes just because they were software, especially if you had to make it all work before you flew. A lot of times, once you got up in flight, you could fix some stuff, and you did because you had to do it, but you wanted to lift off with a system that was a good system.

WRIGHT: You only stayed in that position for a year before you got moved to become Chief of the Payload Operations Branch.

HOLT: Yes.

WRIGHT: Why did they move you over to—

HOLT: My good friend Carl Shelley, who was deputy to Gene Kranz at that time—well, there was two things going on. [James D.] Jim Shannon was running the Payload Operations Branch over in John [W.] O'Neill's Ops Division. At this time, since everybody was getting worried about schedules and all these things—and Jim's very, very meticulous and a very, very structure-oriented type of guy. They took Jim and had him then start working on the operations side of all these schedules and all these templates and all that activity that had to go—and trying to build a system that would then keep up with this stuff.

In the meantime, I had some payload background so they offered me a job to go over there. They didn't ask me whether I wanted to or not; they just offered me the job and said, "The job is over there in that building." So I left a job that I was very happy with and went over and did another one, and I was very happy with that, too.

It was different. When I got to Payloads, we were at the point of getting ready to fly the first—I think we were getting ready to fly Palapa/Westar [satellites]. No, it wasn't Palapa/Westar. That was after I got there.

WRIGHT: You were getting ready to do the first night launch and the first Spacelab.

HOLT: Yes. It was the first Spacelab. All the promises that had been made and all of the processes that had been set up, you now started to see the Orbiter processes play out. You now were to the point where you knew some of the stuff that was going to change on a flight-to-flight basis, based on the changes in vehicle and all. So that was starting to become a little more apparent, how we were going to deal with that. The payload world, then, was right on the heels of "Now you have an Orbiter that's been through a few things. Now it's time to go start working on flying payload content."

The payload process was administered by Shuttle—I can't remember what SPIDPO [Shuttle Payload Integration and Development Program Office] stood for, actually, at that time. It was Glynn [S.] Lunney and Leonard [S.] Nicholson ran the process. The payload integration planning process was a pretty good-sized effort. It had been split up to where the customers had to pretty much—the onus was on the customer to come in and bring you the information. So it was not like what we'd done in the past, where we'd actually gone off, sat down, written it

ourselves, and gone off and done it. So at this point, things were more negotiation-sensitive than they were.

I can remember what I realized when I went into the payloads arena at that time, was it looked an awful lot like what I'd seen when I first walked into Flight Control Division. They hadn't really started flying yet, and they were trying to take what they thought the environment was and trying to map into that. The payload guys were trying to do everything the same for every customer and for everybody, and the environment was really different.

We had a lot of commercial payloads, Hughes 376 PAM [Payload Assist Module] operations with McDonnell Douglas and all. Those guys would hit town with a customer, and they'd sit down in an afternoon and write up the agreements. We had the blank books from the Program Office. Our guys would just go through and fill out the blanks and send it to them. They'd sign on the dotted line and send them back, and they were ready to go.

The same operation with the government. We'd take a government customer like Marshall with the Spacelabs, and they had enough staff to where they—it was like everything was a pull-and-tug, because everything was an argument over control. So we had this back-and-forth with them, and it was all the way up the chain. It was not just at our end of operations side. It was at the engineering level. It was at the program level.

JSC would have just as soon never had Marshall in the business of operating anything, and Marshall would just as soon that JSC would just leave them alone. So we've always had that kind of relationship with the guys in Huntsville.

Then you had the DoD [Department of Defense]. What was interesting there was, the first meeting you'd have with a DoD payload customer was—you could never have much with them, because it was always going to be hush-hush, even if it wasn't. The second meeting you

had was always with a second lieutenant who was speaking for the general and who was not quite sure that he wasn't the general. So, finally, we just got to the point where we had to take and—we reorganized payloads and operations to where we took the commercials and put them in one section, we took the government, Spacelabs and things we operated with JPL [Jet Propulsion Laboratory, Pasadena, California], and put them in another, and we put the military stuff down the hall behind a cipher-lock. Literally, at that point we said, they're not the same, we're not even going to try to treat them the same. You've got to show good for everything. They've all got to go through the process.

At that point we just literally made some simplifications. Earl [W.] Thompson was Director of Information Systems out here when he retired. Earl was my deputy at that time. We had an interesting group. We had a lot of fun.

WRIGHT: You had a lot of people work for you. You had over a hundred people?

HOLT: Yes, we had fifty civil servants in that world, and we had about another fifty level-of-effort contractors. We were all cramped into the upstairs admin side of Building 29, where the water tank was over there—the WETF [Weightless Environment Test Facility].

The thing I remember the most was they'd leave the doors open downstairs because it gets stuffy in there, and we could always tell they'd left the doors open because our computers quit. [Laughs]

That was the point in time where we really started—you asked earlier about that. That's really where we started seeing the effects of technology, because at that point, we had the Xerox Wordstar that we had adopted within MOD. I think Engineering was running on Apples

[computers]. Jack Garman, over in the Data Systems and Analysis side, he was all PC [personal computer, IBM compatible]. At one time, Gene Kranz, the Mission Operations Director, had the largest ethernet operation, Wordstar Ethernet, outside of PARC [Xerox Palo Alto Research Center] out in San Jose or wherever, in Redwood City, and we got the greatest tech support you've ever seen. The problem with it was that the system really was only the secretarial support system, but it was the first real Windows. It's what [William H.] Bill Gates parasited to start up [Microsoft] Windows with. [Xerox sued Microsoft over the design.]

It was a great system. I remember being in Building 29 and handing Connie [R.] Dunaway a set of charts. She could type them and print them out on the server in Kranz's office, and I could pick them up walking into his office.

At that time I learned a lot about how much time you could really milk out of the system with it. [Laughs] And I remember getting burned one day when, all of a sudden, the server wasn't up over there and I showed up with no charts and Kranz is looking at me like, "Well, what are you here for?" [Laughs]

That system made all the difference, because it was at that time—we were getting to the point where we had nothing—in the old days we hired in a secretary for every section, and sections were maybe six to eight people. Here, there's fifty people with one secretary and a helper, and she was in a trainee program.

Connie Dunaway was my secretary at that time, and she had been working for NASA since she got out of high school. She knew everybody, and she was intimidated by none. Every so often, you just kind of needed somebody to guard the moat, and Connie was very capable. You need a very, very mean alligator in your moat, and Connie was capable of that. She loved the role, too.

We had a lot of young people, and a lot of them showed up in different places. I know in that branch, the people that I gave—[W. Michael] Mike Hawes got a section there. [William H.] Bill Gerstenmaier got a section in there, hired several people that are still with us. [James L.] Jim Clement is now Deputy Division Chief in Operations. Kathy Laurini is over in the Station Program Office, because she was the NASA rep [representative] in the European Space Program. We were able to, at that time, attract some really good people. That's a partial list. They had [Robert M.] Rob Kelso over there. It was a lot of people that have done well in their careers.

I had the same good fortune back in the guidance and propulsion systems world. The first section I had, I had Ron Dittemore, Bill Gerstenmaier, [N.] Wayne Hale, [Jr.], Rich Jackson, [James] Jim Oberg. It was really an interesting group.

WRIGHT: That should be an interesting mix, yes.

HOLT: Yes, and they were all extremely competent people.

WRIGHT: During these two positions, the schedule of flights was pretty intense.

HOLT: Yes, it was. They were all different.

WRIGHT: Can you share with us about how you were able to be debriefing one, doing one, and planning the other ones? And with all the payloads being different, you also brought in another Shuttle on board, on flights?

HOLT: Right.

WRIGHT: Give us an idea of what all was going on and how you were able manage all of that at one time.

HOLT: When I mentioned that Shannon had gone off to set up an organization, well, there was a complementary-type operation going on over in the flight software world and in the Control Center world. The Shuttle Program was at that point starting to put real structure into the data products and their timing, and so it was no longer something—early on everybody had said, "I need to know all these inputs by this time, so I need the customers to provide this. I need this from so-and-so," and they had just written it down. Now it had gotten to the point where it says, now you've got to justify why you need it now.

I can remember going to a set of meetings with guys like [Lawrence G.] Larry Williams, who were fairly crusty old guys, over in the Shuttle Program Office. After listening to everybody go through justifications, then Larry came out and said, "Well, we're going to do it all in one day, and we're going to do it right there." Everybody howled and screamed and everything. Larry says, "Well, look, I don't understand what your problem is. You guys today are coming over here individually to tell me all the things that aren't right and all the things that aren't delivered when you wanted them. Now, I want to do that one time. I'm getting tired of having to hear that thirteen times. I'm hearing it from the Cape. I'm hearing it from Engineering. I'm hearing it from Flight [Ops]."

So literally it was the thing that says, we're no longer running an R&D operation. We're now going to make this transition to Operations. When you get to that point, then you just literally don't get to have it your way. This is not Burger King.

It was a tough adjustment. In a lot of areas we got it right, and in some areas we didn't. In that time frame, you had to get—and it was tough on the customers. I mentioned we had had our normal battles with Marshall Space Flight Center. We ran through a flight ops review, which were formal program milestones that we had for the Shuttle Program. We had to take all of the documents and flight rules and procedures and trot those out for the customers and have them go tell us what they liked and didn't like.

In some areas, like the Marshall Space Flight Center and its first Spacelab, the guy over there just decided that he wasn't going to work on all the Control Center displays and stuff until he was ready to, so he just ignored it. When we got to the Flight Ops review, I sat down with Carolyn [S.] Griner, and Carolyn and I—I don't know if you've run into Carolyn or not. She was the Deputy Center Director when she retired, over in Huntsville. She was the mission manager on a flight.

I said, "Carolyn, I've got to have this, and I've got to have it tomorrow."

She said, "I don't understand why this is such a crisis."

I said, "Well, it's been a crisis now, since you guys are now four months late."

She says, "This is the first time I've heard of it."

So they had some stuff to go fix, we had some stuff to go fix, and we hammered it out. But it was that type of thing, that there were some really tough nose-to-nose-type negotiations back in those days. But it got to the point that says, okay, the dates are real, and they're going to

be saluted, and you have to have them. If you can't make them, you'd better have reasons why. Then you've got to go come up with a plan to go put it into place.

At the same time, we did some very creative things. We went and did Palapa/Westar. We did that on a quick turnaround-type operation. In fact, we did the flight operations review before they had completed the design of the engineering for the payload bay, which was—normally that's done first, and then you go do the operations stuff.

I have a picture of that flight, of [Joseph P.] Joe Allen [IV] holding onto a PAM, a 3,000-pound PAM. He's on the foot restraint on the sill holding it with his hands. Dale [A.] Gardner is laying on his back in the payload bay with a four-foot-long torque wrench putting on this thing that you had to have to be able to bring it home in the bay. I thought to myself, I said, people talk about all the things that we do today, yet if you really look back at what we did, it was like, well, that was the only way you could come up with to do it, and so that's just what we did. They'd have never done that today. No way, José.

Every flight had that kind of thing in it. The first Spacelab flight, the crew—John [W. Young] reported this loud pop. Nobody ever figured out what the loud pop was. They figured it was thermal, but it scared the hell out of the crew, and we spent a lot of time, all night long, looking through all the data and everything and never found anything.

It was those kinds of things, to where everything was—you took nothing for granted. At the same time, you had to just pretty much—when a guy told you he thought he could do it, you just let him. It was okay.

WRIGHT: What were your thoughts when they tested the EMU [Extravehicular Mobility Unit]?

HOLT: That was the kind of thing where, on that flight it was like, my god, here we are with—we've been flying now, and we're up on our third flight, and we finally decide to go test the [EMUs]? We've already flown two times assuming we had [an EMU], and neither of [the EMUs] worked. So it was like, here we've been into orbit three times, and we didn't even have an EVA [Extravehicular Activity] capability, although we thought we did.

Those were pretty sobering times. We had glitches in the arms. So it was all of the growing pains of an R&D program, and some of those things were very serious. It was the kind of thing to where it says, "Well, we got away with one."

WRIGHT: While you were the chief on [STS] 51-A, you not only delivered two satellites but you brought two home. That was a little unique in itself. Can you share any thoughts about that?

HOLT: No, that was actually not that big a deal. It just kind of—

WRIGHT: Seemed natural?

HOLT: We had done it before. It was the kind of thing to where you'd done it before. Literally, it kind of got to the point where once I'd done a flight operations review as a Branch Chief, I assumed the flight was done until we got down to go do it. Literally, the whole training period in there was done—my section heads watched out for that. Their guys were part of the flight control team. So literally, unless there was a problem, we had somebody we were worried about on console or certification issues or the flight directors had had heartburn over somebody, and

we had to move people around every so often, but I just pretty much didn't pay much attention to the implementation.

That's part of getting operational. Once I could get to the point that says, "We're lined up, we know what to go do," the team has to go do it. So there was never a problem in operations with accountability. It was assumed that you were accountable. On the day that you were deemed to be not accountable, then it was pretty obvious to you that you were—that was not something that was taken lightly. The day you didn't take the responsibility for your own actions or the day you ducked one, then you were probably a candidate to go find a job somewhere else.

We talk about training programs, and we talk about all that, but we ran a sink-or-swim operation. We give you all the opportunities to train, we give you all the information that we could get you trained with, and we gave you the best structure we could get you into, and if you couldn't cut it, we'd take you out.

WRIGHT: You mentioned earlier that the area was for your customers and your commercial and then your interagency and then the DoD. Were there certain other certification processes that you had to do with DoD differently for their payloads that—

HOLT: No, the real difference with DoD was we had to conduct a lot of our operations behind closed doors and with secret labels on them. So it was an overhead more than anything else. We ran the first flight operations review for the first big DoD payload, and you only had a few places that you could go do them, so we ended up in [Building 1, Room] 966, up in the ninth floor

conference room, for a week up there. Like I said, it was all paper process, so all of the discrepancies came in.

The things that made those things kind of hard, that was easier with the commercial guys, the commercial guys really were more economical. They were in a point that says, time is money. So unless it was a big deal, they didn't bother writing up discrepancies. Some of the DoD contractors were the worst. They got paid by the discrepancy notice, so you ended up with a lot more overhead for some of their flights.

The first time we ever ran into Aerospace [Corporation], who was the system integrator for the Air Force, it was like, "Who are these people?" It was like dot every *i* and cross every *t*, and it was like, "Good lord, here we go again." We learned. We very much had a disdain for some of the people we ran into and the way they did business, but that was their business model.

WRIGHT: How did the slippage in Shuttle flight schedule affect your job as a payload operations?

HOLT: Well, not that much. Once you got it going, you bought time, actually. You had to redo some things, and you always had a re-planning process. When they pushed flights too close together, then the guys—the guys that were doing the facility turnarounds had the biggest single problems. They literally had to be able to get one set of customers off of consoles and onto others. This was in the days when all the consoles still had those lights on them, and all this stuff was running off of the old [system before PCs]—it wasn't running on PCs [yet]. We were literally making the transition in that time frame. So we didn't have the ease of reconfiguration that the system does today. We got some gotchas. Every so often we'd find one. Then we'd go

figure out why that happened, and we'd put a process in place to make sure it didn't happen again.

A lot of times, you got to a point where you had to go identify somebody who was going to be accountable for it and somebody who was going to put the system on notice as to when things had to be done, because we didn't have the neat template charts that the Shuttle Program runs and the Station Program just run with today. They're up and they're running on big interrelational databases. You put the one number in, it changes everything across the system.

Well, that wasn't that way. We had systems that were diverse and they didn't play with each other. It was a tough environment. Holding it all together was an awful lot of baling wire and chewing gum.

WRIGHT: This was a time, too, that NASA was dealing more with international venues, with the European passengers, Canadian crews. Did that affect your job at all?

HOLT: That made it fun, because the diversity has always been part of the fun of doing this business. Doing the same thing over and over and over again wasn't what people signed on to do. I think, in today's market, finding guys who want to sit in the Control Center day in and day out, you have to have those people, but they're not the same people that you went to the Moon with. But a lot of those guys that went to the Moon go stir-crazy doing those jobs. So it's that balance of the guys who just want to come in for the excitement, the fun, and when it's over with, they'd like to move on, versus the guys who really like to do this for a living and are satisfied with making every shift count and making small changes here and there, and that's what punches their ticket.

WRIGHT: Did you have any challenges working with international customers at this point?

HOLT: No. Most of the challenges internationally were just the—it was always the first-time-education-type thing. They were eager to work with us. That was not a problem. The Europeans were in it to learn, because they wanted to do it themselves. At the same time, they did learn, and a lot of the lessons they learned were things that said, when we get around the Space Station, we aren't going to do that again. So that was the kind of thing. But the first time through they were more than willing to go through our processes.

We were starting to see some of the vestiges of international competition. I know Mike Hawes had gone out with the [Space Shuttle] Program teams and had done a set of briefings, had gone around to India and several different countries making a pitch. One of the real criticisms of the Shuttle at that time was the numbers of products and the numbers of interfaces, because if you wanted to go ride on Ariane [European expendable launch vehicle], for example, you didn't have to go do but four books, and with the Shuttle you had to do eleven. It was that type of thing. It was known then that there was going to be competition.

What I think was the thing that caught everybody by surprise was how invasive the concept of crew safety and operational safety was going to drive everything you did. It's obvious when you think about it that that's the case, but when you build up an unmanned spacecraft, safety is something you deal with on the ground, and then once you light the match, it's over. So you deal with reliability and quality issues in your ground safety program.

Well, here you had to fly your ground safety program, and it also had to be a flight safety program. It also had to be a return-from-flight program. So you had a lot more activity and a lot

more of everything—like if your payload didn't operate, you didn't worry about it on the ground. Well, it operates in space. So now is it safe? So the payload safety environment was always a big driver on the operation, and it was always an extreme irritant for the payload customers, because they had to produce so much more information than they normally had to go fly any unmanned satellites that they had been accustomed to. Typically, those were the guys that we did business with. [C. Harold] Hal Lambert, [Jr.] might be able to give you some really good perspective on that.

WRIGHT: Okay. Well, we're at a point where I think we'd be able to stop in a few minutes, but before we do that, I wanted to see if there was anything else about this time period that we talked about today that you might have thought about but we didn't get a chance to talk about.

HOLT: Just to couch the environment, we had all those years to where we hadn't flown anything, and we'd been getting ready to fly, and then we'd been getting ready to get ready to fly. So all of a sudden, from this time, we'd hired a lot of people. George brought in a lot of people into Operations starting about 1978, '79, '77. So we were at the point where we had hired a lot very good young talent, and a lot of those folks were becoming big producers, because they now had five years.

At the same time, a lot of guys that had been around for a long time had five years' experience, too, and they were fifteen years older, or ten, or whatever. It was becoming really obvious to us that a lot of the young talent was moving really fast. So promotions in that time—it was the kind of thing that says that if you didn't get yours in a hurry, you were going to get run over.

I know if you go back and think in terms of the guys that did Apollo 11, Gene was thirty-five. Don Puddy was thirty, in that range. Steve Bales was twenty-seven, twenty-eight. We were a couple of years younger than all of them. We were twenty-four. When I got my section, I was thirty-five years old. I had five rejection slips when I got that one, because we had just now started staffing up. George had done a pretty good job of finding opportunities for guys that he didn't think were going to be part of the future of flight operations over in Building 1. He'd managed to usher them into jobs over there and managed to get them out, and Kraft helped him. So that opened up section jobs for a lot of us.

Like I say, it was the kind of thing back in those days where you applied, and you hoped you got it, and I finally got one, and I got it outside of my area of expertise. There was no way I was a propulsion guy. But Steve Bales was the Branch Chief, and Steve says, "I don't need another propulsion guy. I need somebody to organize what's here." So that's what I did, and it was a good—they really were. They were excellent. You got three Program Managers out of that crowd, and there's not much you can say about that.

Then the same thing over in the payloads world. It was like there's always the—you're in the startups, and if you liked to do startups then you're in hog heaven. The nice thing about startups for those of us who do like to do them is you can make your own rules for a period of time until they catch up with you. You can take what works and use it, and what doesn't work, you can discard it and move on.

So we had a lot of young talent again coming into the program. We had a lot of opportunities for landing parties, again. And there was time between them to where you could really—the flights started and the flights ended. Station flights really don't end; they just keep

going on and on and on. It was that kind of thing to where you knew you had a pretty good time of it.

We would have never had a problem keeping up at a flight a month or even eighteen months. If the vehicle and the system could have processed them that fast, I don't think it would have been a problem running them, because you would inherently have missions that you could implement, because you wouldn't have been so—try to optimize everything to the extent that you have to. Today you optimize the flights, because flight time's precious. The fifty-two-flight-a-year Shuttle was a non-optimized system. I know when Don Puddy in the GNC Branch, we were at the point where we were supposed to start operating the new operating concepts. We were supposed to start evacuating the front room in the MOCR [Mission Operations Control Room] over there and having guys then operate out of the back with a shift supervisor back there. [Richard N.] Rick Fitts was the section head that took over from me after I moved out of the prop section.

I asked Rick, I said, "Rick, let's just go through and figure out—." And Rick's a tremendous analyst. I said, "How many people difference is it to do what we're talking about here with people in the back room versus if we just stayed with the Control Center model?"

He went back and ran the numbers, and it turns out it was six people total in the Flight Control Division. So we went back and talked to Don. We said, "Don, this not going to work, because the Flight Director is going to sit out there." Don had been a Flight Director enough to know. He says, "The minute something comes up, he's going to want to see your happy smiling face out there in front of him. He doesn't want to talk to you back in some back room and talk to somebody else in some back room. He wants everybody out there on console."

So that was not exactly the cheeriest news that we got to give at that time, and apparently we let a budget cycle go by, but then we didn't know anything about budgets cycles at that time. We didn't worry about it. But we were able at that time to go change the thinking. Even Gene had to admit that, yeah, that's not going to work.

We had a couple of other things like that. I know that the day we were sitting over in the Payload Ops, and we were responsible for setting up—had a group that also did the Control Center configuration. At one point in time, there was scheduled that the Mission Operations Director, who at this point in time would have been Kranz, that console was going to leave the Flight Control Room. The guys that worked for me came around, and Lyle [T.] White—and Lyle's just was a real old-timer. Lyle was born old. But he came around, and he says, "Now, I'm just going to tell you this once, but you need to be aware." He says, "We're not going to have a mission operations console in the Flight Control Room after this flight out here," whichever one it was.

I said, "I don't understand that."

He says, "No." He says, "It's been in the plans that way."

I said, "When was it put in the plans?"

He said, "About six years ago." He says, "So the guys over there are planning to take that console out and reconfigure everything."

I said, "Now, are you sure that that—?"

So I went gingerly around the system and everything. I was talking to Gene, and Gene says, "Well, that's right. I'm not going over there anymore. We're not going to have that console position. We don't need it. I'm going to throw that back room—I'm going to give it all to the Flight Director and let them run it."

I said, "Okay."

As he was talking, Cliff Charlesworth had just come in. By then we were starting to reorganize. Cliff says, "We're going to do what?" He says, "You're not going to do that, are you?" He says, "How are you going to keep those guys out of there anyhow?" [meaning the Shuttle Program management] He says, "Gene, you don't want to do that." [Laughs]

Gene says, "I really don't want to do that, but I don't want to give up the whole plan."

Charlesworth says, "You don't want to do that." [Laughs]

So we went out of there, and Gene says, "Well, just go tell them that we want to delay it for a while."

So I went back and told them it was going to be delayed, and of course, the next thing you know, they all go up in smoke because they got five years of planning. [Laughs]

So those were the kinds of things that say you get your plans in place, and you plan to go do them on a schedule, and the whole system lines up to go do them on that schedule, and then typically you get close and you say, "God, that doesn't make any sense. We'd better stop." Then it gets kind of ugly. So we saw some of that.

So I expect that next time, if you think about all that—then when the STSOC [Space Transportation System Operations Contract] contract came along and all that, that was part of an agency initiative at that point in time, because Jim Beggs was running the agency by then and it was part of the [President Ronald W.] Reagan Administration. He brought in [James A.] Abrahamson from the DoD, soon to go to Star Wars, and the whole thrust—the Cape was doing a Shuttle processing contract. It was a big completion form contract. Our piece was to do STSOC for STS operations and consolidate all that work completion. The head-shed, out of

Washington, was going to get its control over Shuttle operations by forcing the way we did contracts.

I think next time we'll just spend a little time talking about some of that, how much fun I had with all that. It was interesting.

WRIGHT: It should be interesting.

HOLT: It was. It was very interesting.

WRIGHT: So we look forward to the next time we visit.

HOLT: Yes. I enjoyed it.

WRIGHT: Thank you.

[End of interview]