ORAL HISTORY 9 TRANSCRIPT

GLYNN S. LUNNEY
INTERVIEWED BY CAROL BUTLER
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BUTLER: Today is January 13, 2000. This oral history with Glynn Lunney is being conducted in the offices of the Signal Corporation for the Johnson Space Center Oral History Project. Carol Butler is the interviewer and is assisted by Kevin Rusnak and Jason Abbey.

Thank you for joining us again.

LUNNEY: My pleasure to be here, Carol.

BUTLER: Thank you. Last time we were talking about your work with the Shuttle payload integration. We talked a little bit about the work you had done up at Headquarters. Then you came back as manager of the National Space Transportation System. That might be a good place to pick up, what your roles and responsibilities were there.

LUNNEY: Okay, let's start there. That's a good place. The first flight of Shuttle, STS-1, was April of '81, and it was, for a lot of people, men who were involved in the program at the time, it was kind of the culmination. A lot of them had spent ten years or so in the development of the Space Shuttle.

Bob [Robert F.] Thompson, for example, comes to mind, who was program manager here at JSC [Johnson Space Center]. But there are a lot of others. You could tell that emotionally they had set the first flight as their goal to get through, and then they were ready to do something different. As a matter of fact, Bob Thompson, as the manager of the program, was one of those who found himself in that condition, and he decided that he would do something different at that point in his life. And a number of other key players either at

that juncture or soon thereafter, specially those who had put ten years into the development of this system, began to think about something else that they would do, and a number of people dropped off and found other avenues and so on.

I had been active, as you know, in the payloads office for five or six years leading up to the first flight, so I had an involvement with the Space Shuttle program, but mostly from the point of view of accommodations for the customers, and I hadn't really been involved in the development of it per se.

Let's see. In '81, I guess I was about forty-four years old. I had about ten years' program management experience at that time. The Shuttle was a tremendously big job. I guess I never thought about that very much, or it never caused me to be in awe of what I was stepping into, or afraid of what I was stepping into. That's a better way to say it. But I was very respectful of the tremendous development and the tremendous system that had been built. By "system" I mean not only the flight system, but the ground systems at the Cape [Kennedy Space Center, Florida], the systems here in Houston, the simulators, the control center, all of the test facility, the contractor facilities around the country. It was a massive program, and I probably was kind of unaware of all the dimensions of it as I stepped into that. But, nevertheless, like a lot of things that happened in my career, it was just time for me to do something different, and the right opportunity opened up and people let me try it. So I did that for about four years, I guess, from that point on.

At that point, having flown one time, there were still enormous challenges in the Shuttle program. Number one, we had to complete a number of other orbiters. We had to complete a lot more engine development testing. We were still operating the engines at kind of a derated power. We had a lot of things that had to be improved in the SRBs [Solid Rocket Boosters], a lot of things in the tank [External Tank (ET)], a lot of things in the ground system. So it was kind of a pervasive set of things that had to continue to be refined and updated as we went forward, but through all that, as in all of our flights, the first priority

was that we be sure that we were doing something that was safe, that we understood what was going on, that we had controls over things, and that the flights would be safe.

We had also this idea that we were going to run a series of development flights. Originally it was six, and somewhere along the line it got cut to four flights that were called OFT for Orbiter Flight Test. The idea was, we could validate all of the design and testing and the certification of those designs with a series of test flights that would number eventually a total of four, a fairly small number of flights, by the way, to certify something this big.

But there was also this kind of a drumbeat that we had, or almost a mantra at the time, about becoming operational, and by that we meant that we could quickly move up the flight rate, move up the ramp of flight rate, and begin to fly the system more and more often, with some relative ease. That's a poor word, but some relative ease in being able to turn the system around and launch it, and launch it on time or close to on time, etc.

So we flew the first four flights with ejection seats in the vehicle and two people. Because of the ejection seats, we could only fly two people in the vehicle, and that's the way we were configured for the first four flights. But we knew we had a lot to do. We knew there was still a lot of resistance to the program. A lot of people still kind of resented the fact that the Shuttle was going to become the only launch system that the country was going to have, and that carried over into the follow-on years. We had this idea of moving this thing into a relatively—I don't want to call it routine, but relatively standard way of getting on with things and getting flights flown and so on.

We also had this fairly large buildup in flight rate, and that required continued investments and upgrades in the airship itself and in the ground equipment so that we had to build the infrastructure and have the spares available and have the SRBs in the pipeline and the tanks in the pipeline so if something went wrong with one of them, we could move the next set of hardware up, or whatever, and be ready to fly on time. So we had this idea of

putting enough infrastructure in place, and by that I mean equipment, flight equipment and ground equipment, the people, the procedures, and so on, spares, so that we could reasonably expect to make the schedules that we had and move up the flight rate curve.

At the time I moved into the office, Leonard [S.] Nicholson took over the work associated with the payloads and the payload integration, and he had been an absolute giant in that work up until that time anyway, and so his attention was focused on handling the payloads of customers and getting it ready. When I moved into the Shuttle office, my attention was more on how do I get this large system of stuff, people, and equipment ready to do what we had to do in terms of moving up the flight rate.

I might talk about the job that I moved into. First there was kind of a hierarchical structure that everybody found easy to talk about and relate to. The program was being run in what was called a lead center concept, that is; that one of the centers had the overall program management lead, and it was JSC at the time and still is, but it was JSC. That level of office, which is the one I walked into, was called Level Two. Level One was the program management function that existed at Headquarters, the NASA Headquarters, and Level Three were the individual projects, the hardware projects, such as the orbiter, the engines, the tank, the SRBs, and so on, including the ground facilities at the Cape. That was considered to be a Level Three project.

The control center here and so on was by the same model a Level Three project, but it didn't quite get treated the same way for reasons that I couldn't tell you what they were at the time. But the Level Three stuff at the Cape was much more involved. It probably was because the equipment and the procedures and so on that were being put in place at the Cape interfaced directly with the hardware, the vehicles, elements that all the other projects were building. The mission operations interfaces with the vehicle, but not in the same way as you do at the Cape with all the equipment.

So within that construction, I, of course, reported to the center director here in Houston, and the other projects reported to the respective center directors at the other locations, and in years to come, people found a lot of fault with that. They felt that the lines of authority and command were a little blurry and that it was difficult to explain what the program's role was vis-a-vis the center, and what the center's role was vis-a-vis the program and so on, and what those interactions might be.

I must say that I never felt very troubled by that. I always drew a lot of comfort from the fact that the center directors were very bright, capable people who brought another dimension of maturity and experience and so on to the program, so their acting as kind of an oversight group and at times telling us what to do, but was useful. I found it to be comforting as opposed to confusing, although other people found it to be confusing. I guess I grew up in it and I grew up with all the people, so it never was that kind of a thing for me, but if somebody wanted to come in and draw straight lines of command and control, then it would trouble them some. And I could understand that, that it would be so.

One of the things I had to think about not immediately as I got into the job, but as I went along, was, you know, what is it that I'm going to do in this program? It would be very easy in that job—as a matter of fact, it's very easy in any job when people are promoted, to kind of over-manage the next level down and second-guess everything that they decide, and spend all your time involved in essentially your subordinates' business. I tried to find a way not to do that, so that I was doing something that was different from what they were doing, but what I was doing would also add value and add substance to the overall program.

I began to conceive of my role, or the role of the Level Two program office, as one of kind of setting the agenda. The agenda would be challenging. By "agenda" I mean the flight rate, the content of the flights, and so on, the schedule for upgrades, etc. Set the agenda for the overall program, make it very challenging, but make it doable. And then to be an advocate for the program with the many people that we had to interface with, especially

interfacing with the NASA Headquarters, where we had to advocate people for jobs, we had to advocate changes in the vehicle, we had to advocate budgets and so on. So I tried to find a role of continuing to set a challenging but doable agenda for people, and then support them as best that I could.

As a matter of fact, I found myself many times, as I had in previous jobs, dragged into levels of discussion on the kinds of things which I didn't feel very competent in. I had no illusion. I am not a designer, never was, never will be. My brother could take cars apart and put them together when we were kids, but that was a talent that was not in my makeup. I guess I had other talents perhaps more obscure. But I tried to find a way so that I was not tripping over the projects, and giving them room, letting them know what they had to do, when they had to do it by, and so on and so on, and then going out and doing all that I could to help them in prosecution of their daily jobs.

So it was quite a challenge to find how to do that, and it was a matter of setting a pace and having a balance between not having too many near-impossible things at the table at one time, but setting a pace to it that we'd have a reasonable chance of pulling off, although certainly it never was a piece of cake in terms of ramping-up the flight rate chart.

Let's see. There were a number of, I guess you'd call them interfaces or zones of interaction with different kind of people. Let me talk about a couple of those. In NASA Headquarters, somewhere right around this time, or maybe a little before that, Mr. [James M.] Beggs was the new administrator of NASA and Hans Mark was his deputy. I was fairly remote from their level of stuff, whatever they were doing with official Washington, but, nevertheless, they did occasionally impinge upon my life, and in one fashion in particular, I should say, in one event in particular, they impinged on my life in a significant way.

At that time, there was some government federal situation that I can't describe very well, but it affected people who were near retirement age. My understanding of it was, if they took a retirement, then they could lock in certain benefits that if they waited, they might

lose or they were scheduled to lose. I'm not sure what they were. So a number of our senior people took that kind of a condition and then just continued in their work and they got a new title or a new label, and it was called "retired annuitants." This is kind of a top-level view of that situation. It's probably more complicated or whatever than that.

But Chris [Christopher C.] Kraft [Jr.], who was the center director at the time, was in that condition. He decided that it would be best for him and his family, and a number of other people, Max [Maxime A.] Faget, Deke [Donald K.] Slayton, and others found themselves in that condition where they took this option, I suppose you'd call it, for retirement, but continued.

Now, in a sense—some other things. On STS-2—I haven't gotten to the flight sequence yet, but on STS-2 we had an APU [Auxiliary Power Unit] problem at the Cape and we had to scrub. But I remember in the immediate—maybe even prior to, but immediate aftermath of that scrub, there were some rather heated conversations with Washington Headquarters, especially the administrator, the deputy administrator, Jim Beggs and Hans Mark, and heated in the sense that Chris Kraft was involved in them, and he was fairly adamant about the position that we took, which, by the way, even today, looking back on it, I think was absolutely correct. We had this problem, we had to scrub for it, and so on and so on.

Anyway, on the net and somewhat exposed to everybody was this rather strong debate about this scrub and whether it should have occurred or not. I don't know whether it was that or other things, or a combination of things, but that was the visible sign that I saw early that things were not well between the front office and Chris. And then the fact that Chris was in this status, this sort of limbo status, I guess you might call it, this retired annuitant, it didn't have the same security in the civil service sense as his previous status. That was used ultimately to remove him. As a matter of fact, in August of '82, Chris resigned, retired, whatever the right term is, and I felt like I had lost a leader, lost the leader

that I'd had for so many years in the program. As a matter of fact, many, many other people felt the same way.

Somewhere in that same time frame, Max probably left, and Deke Slayton, who I had the greatest admiration for, Deke, in effect, was working for me. He was part of the program office at the time and was always very helpful to me and so on, but it was kind of odd for somebody at my experience level to be managing Deke. But it was very cooperative and went very well, and Deke was left with this not knowing what his condition was. So for me it was very sad to lose that kind of leadership.

BUTLER: Understandably.

LUNNEY: And more than sad, it was bad for the program, in my opinion, and it kind of left us a little wondering what the hell was going on. As a matter of fact, also it was possible that I could have been considered at that time for Chris' job, but I had the feeling that I wasn't, one, maybe because I was too closely identified with him, which, by the way, given a choice, I would still choose to be identified that way, and perhaps some other things.

At any rate, I was sort of passed over for the center director job, which still would have been at a pretty early age, but it kind of left a kind of funny taste in my mouth. Plus, I had watched the congressional delegations over the years visit this center or receive us when we went to Washington, and always with a great deal of fluff and attention and fussing around paid to people, especially key players like Chris, but he was in this condition of maybe he's going to stay and maybe he's not for almost a year or thereabouts, from probably the fall of '81 to August of '82, and he was kind of twisting in the wind a little bit. At least that was my sense of it. I thought it was kind of an unfair treatment. But all these politicos that were so fond of him personally and also involved in a congressional way with the programs, nobody lifted a finger to help any of those key players.

So for me, again, watching that kind of a lesson in terms of how much people really mean and how much sometimes they don't mean in things, and maybe they felt like they shouldn't interfere in those kind of decisions and that would probably certainly be the attitude today. In those days it was less clear that that was the case. I think the congressionals could have intervened in any case like that and made a difference, but, to my knowledge, they never did. And by the way, I say to my knowledge. They may have and not taken, but it didn't seem to me that all of the good that Chris had done for the program and the people around it, I didn't see any support come to him because of that. It's kind of a disappointing lesson to learn at that stage of my life.

So anyway, at Headquarters, below the level of the administrator and deputy, there was an office called the Office of Space Flight, or maybe it was called Office of Manned Space Flight, I'm not sure, at the time. [Lt.] General [J. A.] Abrahamson, who was new to NASA, came in from a long history in the Air Force, and he was the administrator of OSF and was also the kind of acting program manager, program director, I should say, at the Headquarters level.

"Abe" was an interesting guy. It was one of the first times that in my career I'd met somebody and worked closely with somebody from outside of NASA, and he had kind of a different style of things than anybody that I had ever run into before. Frankly, I found I spent quite a bit of time corralling his what appeared to me to be kind of tangential initiatives of various kinds. I always had the feeling I was trying to get him back inside the fence so that they were doable. But he had a knack of finding miscellaneous—I don't want to say miscellaneous, but somehow not mainline, but different kinds of things that he would keep bringing into the program. It gave me some trouble and some gas as we went along, so I always worked at trying to control Abe.

But Abe found his role, and they had other people there. They had—I don't want to say a large staff, but they had staff that was probably measured in dozens of people in this

office, and some of them had useful, constructive things to do, but some of them were, in effect, following the actions of the Level Three projects in the program, engine people, tank people. So I think it was difficult for them, and there was probably some degree of frustration because they didn't have a hands-on job and yet everybody asked them about the engine and the tank, at least in the Washington environment. When they were the only person available, they would get asked all the questions. So it was probably a frustrating job for them.

What we were trying to do was keep everything under control and not allow side conversations or side channels for direction or anything that would confuse the program, and there was always a kind of tussling at that interface to be sure that Headquarters wasn't sending some of our team off in some direction other than the one we had here, and that we thought everybody was executing the same play. So it was that kind of a situation, and they had talented people and they were motivated, so they always wanted to do something, but sometimes that doing something can create problems. Sometimes it's helpful, but sometimes it creates problems, too. So we had to watch that kind of stuff.

We had a Level Two office here at JSC, which is where I was, and it had a title that became National Space Transportation System, but probably better known as the Space Shuttle Program Office, although that name got upgraded for a while. The people at the Cape were active in the program—Bob [Dr. Robert H.] Gray, Bob [Robert B.] Sieck, and others. I always found them to be very, very helpful.

The Cape has a difficult role in the program. They're at the end of the line. All of these engineering teams and fabrication teams build all this hardware and ship it to them, and they always have all these requirements about what should be done, what shouldn't be done with their hardware, and the Cape strives to honor all of those requirements. Sometimes they can't fathom why a requirement might exist, but they're at the end of the line and all the work eventually has to catch up and get done. Sometimes that happens at the Cape. If a problem

occurs, sometimes they would think that it's easy to resolve, but the engineering teams would want more effort, for example, to resolve the problem than the launch team might otherwise think necessary.

So because of the nature of their job and because it was such a large workforce, mostly a technician-level workforce, they were the tail of the dog and they got wagged a lot. But they were always very "can do." I always learned to wait them out a little bit. Their first estimate for anything was always long, their second estimate was somewhere medium, and then their final estimate, or when they'd finally get around to doing the job, it usually got done pretty fast. So everybody learned to calibrate it and kind of wait a little while until we got done with that wave.

I had good interaction with the Marshall projects. Bob Lindstrom was kind of the chief, and he had the tank and the SRB and SRM [Solid Rocket Motor] and the engine over there. We found them to be very helpful, very professional, very good at what they did, very, very good at what they did. They were very cooperative with the Level Two office. I think Bob Thompson had done a lot to set that, and I tried very hard to keep that going. We had a number of off-site team visits before people had invented those and had a name for them. We used to do that and play some golf once in a while if we ever had time to do that. But we had a lot of good teamwork and a lot of involvement, a lot of people, and for me it was pretty comforting. I always felt like we had a very, very solid team.

The team here at JSC, Max [Faget] was in the office when I got there. He was very helpful to me in terms of learning the system and some of the things about it, as was all his engineering team. I was always amazed at the engineering team. You'd get a call from the Cape that there was a problem, and by the time you walked out to start making phone calls to get the guys over to talk about it, they were sitting in your outer office and ready to talk about it. So the team here of subsystem managers and their support teams, they were just great, and it was great to work with them.

[Chuckles] Speaking of that, Don [Donald D.] Arabian ran what was called the Test and Evaluation Office, or something like that, and one of his functions was that he would run this mission evaluation room during real time where, when problems occurred in flight that could be beneficially looked at by the engineering team, Don and his staff kind of ran those things, and Don often ran many of them himself, especially the ones that were either urgent or critical.

Don was flamboyant, smart as a whip kind of a guy, but difficult for people to control. It was impossible for people to control him and so on, and he used to terrorize the engineering team in terms of his demands for this and data for that and tests for this and so on, and for clear thinking, in my view. He always demanded clear thinking, not some muddled-up answer. [Chuckles] There were times when I used to, if things were dragging on the resolution of a problem, I used to threaten the engineering team with "getting Don Arabian to look into this if you guys don't get this thing fixed." [Laughter] So he was great.

Gene Kranz was running Mission Operations Directorate, and Gene and I had worked together for years and years and years. The mission operations interface was very good, and I always felt a great deal of confidence when I was the program manager and walked into the control center in flight, because I could kind of sit back.

On the first couple of flights, that wasn't quite true. For reasons of not getting it clarified very well, I was involved in more of the weather calls than I should have been. There wasn't anybody else to call. We didn't have anybody assigned, and we didn't really have all the weather maps and all the stuff that we have today. So it was a little bit more seat-of-the-pantsy, and there wasn't anybody exactly picking up that job, so they'd ask me, "Are you ready to launch it? Is weather okay?" So I'd decide whether it was okay or not. It wasn't done the way it should have been.

MOD [Mission Operations Directorate] picked that job up after the first couple of flights, and after that it got done much more rigorously, had all the stuff in place, the radars

and the weather reports. They made much more of a discipline of it than I ever had time to do, because I didn't even get around to that until the last couple of hours before we were ready to launch something.

Lyn [Lynwood C.] Dunseith was in the data systems job. He was the guy that built all the facilities that we used on the ground and control center and so on, and the flight software. Lyn, I always thought the world of him. We worked together for many years starting at the Lewis Research Center [Cleveland, Ohio], at Langley [Research Center, Hampton, Virginia] together, down here, and it was great.

The Astronaut Office was interesting. George [W. S.] Abbey was running the Astronaut Office at the time, and it was quite an eye-opener for me. I had worked with the astronauts a lot as the flight director, but it was interesting to work with them as the program manager, where I was more involved in different things. I did the same thing for Apollo-Soyuz, but there was a lot more going on in Shuttle program.

For example, well, they made a point of taking me up in the Shuttle training aircraft and taking me through the flights to see what a landing was like and a simulator, and they made a point of showing me what things were like from the point of view of the EVA and so on, in the water tank, although I didn't go in there. I had a chance to watch it and listen to it a lot. So they went out of their way to be sure that I knew what was facing them as they did this thing.

But they're an inventive lot, the astronaut corps, and they were always coming over with these ideas for adding things to their flight. In other words, once they got assigned to it, it was like a little curve you could almost spot. Once a crew got assigned to a flight, there would be about three or four proposals to add stuff to the flight. They loved to add EVAs, space walks. We were trying to keep everything contained, so we weren't adding new work all the time, new things. So we kind of had a running, ongoing thing about what are we going to add to these flights. But I tell you, they're very inventive. A lot of times we ended

up doing some of the things that they invented, and they were constructive and helpful to the program.

They also had this thing about landing. Oh, I mean, we had more debates about where to land, that is, to land at Kennedy on the runway that we had built, 15,000-foot, beautiful runway, although the shoulders were not too good and so on. So there were a number of things about it that people could complain about, including the weather. But they also painted this picture for me on how wonderful Edwards [Air Force Base, California] was and it's always nice out there and it's always great to land and so on and so on. That returned to plague us early in OFT [orbiter flight tests] on the third flight. We couldn't go to Edwards because the lake bed was wet from raining and so on. So I kept running into this—I called it the Chuck [Charles E.] Yeager syndrome about going back to Edwards all the time.

The Kennedy guys were frustrated by it. It always took an extra week if you landed at Edwards, to secure the vehicle, put it on the 747 and fly it down to the Cape. So when there was a lot of pressure on schedule, which there always is, it always seems like landing at Edwards would introduce another week to the cycle, and the Cape guys were naturally, this was one of the frustrations that they had because they're at the end of the chain and they didn't get to decide, really, where we would land. But the astronauts did. God, they could think of more reasons why we had to land at Edwards, you know, and I used to try to get them to make a list to see if we could work it off, and then every time we'd get so far down the list, then the whole set of discussions would change, on and on and on.

The other thing that was going on was we began to consider a payload specialist, and we've sort of lost track of that by now, but at the time it was fairly controversial with the astronaut corps. They saw themselves as professional astronauts specially trained to do this, and to some degree they resented these non-qualified astronauts showing up and getting a seat assignment, especially when seat assignments were the most coveted thing that the astronaut corps had in its agenda. So payload specialists were viewed by them as a threat.

Payload specialists from the outside generally bumped somebody from the inside, so there was a lot of tugging and pulling on the subject of payload specialists. It gradually worked itself out and reached a level that was acceptable to people, but especially on the front end there was quite a bit of controversy about it, and it didn't go all that well.

We had a lot of outside review groups, ASAP, the ASAP panel, and dozens of others would come through, and we would have to present the status of the program to them and so on. The review groups have a difficult assignment, because generally people are looking for some new insight. The problem that review groups have is, they're always operating from a set of facts and information that the program provides to them. It isn't like they can directly experience themselves what's going on in a program and derive their own set of observations. They generally are receiving a set of observations and then deal with the question of are they interpreted correctly. So in general, review groups have a hard time finding, I think, fundamental insights to make things better. At least they did in the experience that I had. I don't think that has to be true, but it seemed to work that way.

The other major interface that we had was DoD, the Air Force, Department of Defense, and they were off at this time busily building Vandenberg [Air Force Base, California]. This was a new thing for us, another launch site on the West Coast, to go polar. Launch south out of Vandenberg out of the Pacific and you go polar orbits. And so they had a fairly big effort out there, of course, building this launch pad, and we had a lot of support to it because we had to provide a lot of support from the program to it, so we were involved in a number of ways, which was new to me from my previous experience, which was primarily on the payload side.

By the way, Vandenberg was a tough place for us, for the Shuttle, because it's very windy and it tends to be kind of rainy and cloudy, so a difficult launch, but even more difficult landing site for the orbiter, and it was generally conceived the flights would return

and land there at Vandenberg once used there, just as we were hoping to get to that condition at the Cape.

Security, control mode stuff continued, mostly handled at this time by Leonard [Nicholson] and his guys, who were fully incorporated in the Shuttle program office very soon after I moved over there, but they had a lot of things to do in that regard. The IUS was still in development, the Interim Upper Stage, that the Air Force was building, classified payloads.

The Air Force also had requirements that were driving the performance of the vehicle. By performance I mean how much throw weight, how much payload we could put in orbit, and they generally had reasons to want to have more payload than they now had and sometimes more payload than we could deliver. I talked about that in a previous session.

One of the things that was instituted while I was in the Shuttle program was, we went off to build what is called a filament-wound case. It's like a fiberglass case for the solid rocket motors. They were steel at the time, of course, steel casing, so we went off to look at this filament-wound case, which, by the way, is what a lot of solid rocket motors are now made of. They're made of this filament. It's called filament-wound, but it's like a single thread in fiberglass built up with various resins and so on to make a very good structure. We spent a lot of money on that—well, spent a lot of money on a lot of things, but that was well along in development. It probably would have gained us—I can't remember the numbers—five to ten thousand pounds of performance, so it was a big improvement.

But we never did get to complete it. Eventually the *Challenger*—the Air Force got out, Vandenberg went away [in regards to the Shuttle], and the requirement went away. But they used to just constantly drive us on the subject of how much throw weight we could put up, called performance, and it was a major consideration in the program.

Because we were launching out of the [East] Coast of the United States, launching [east], early in the Shuttle sequence, as a matter of fact, I think probably about the time of

STS-1 and certainly STS-2, Joe [H.] Engle began to experiment with these transatlantic landings, so that when you go up—up until that time it was conceived that you would either come back to the launch site or go on to orbit somehow. Well, Joe started to work in the simulator with, well, when I'm in this in-between zone, why don't I land in Africa. It sounds sort of obvious now, but in the beginning of the program it was not an abort mode that was operative or had been analyzed.

Now, I say Joe because he's the first person I remember talking about it. Other people might have been involved. Joe Engle, that is. Other people might have been involved, but Joe was the guy I saw bringing the idea of a transatlantic landing to the program, and in a similar fashion, when we thought about Vandenberg, we were looking at islands or landing fields down south of Vandenberg, and we actually had survey teams that had gone out to Easter Island, because, it turned out, was kind of on a line south from the Vandenberg launch site. It had a very short runway and it was very unforgiving on either end of the runway, as I recall. I hadn't been there, but as described to me. But it was sort of a last-ditch thing that we might do.

The other thing that the Air Force was really hot about was for some reason that was never explained to me, they had this requirement that the vehicle be able to fly cross-range a long way. I don't remember the exact numbers, but let me say 1,000 miles. They wanted this thing to be able to fly 1,000 miles off the orbital track to a landing site. Now, when you went polar out of Vandenberg, south and came around, you're about 1,000 miles away from Vandenberg, so that has some rationale for it. But we found that the design of the vehicle in a thermal sense didn't lend itself to going that far, so we were looking at ways to take care of the abort modes and live within a constraint of a cross-range of about 700, 750 miles.

In consideration of that, we began to look at air fields like, for example, up in Alaska, cold and everything and bad weather and so on, but, nevertheless, we were looking at places to land that would still be available to us that would diminish the requirement for the large

cross-range and help us with the design that we had of the vehicle, not have to modify it any more.

That was a peculiar discussion with them, because they just seemed adamant about the cross-range, for reasons that I could never fully appreciate. I'm sure they had some, but it was difficult for me to really get at, one, what the reason was, and, two, why did they care, as long as we landed the vehicle on the abort at an acceptable landing field where we had the proper degree of security? We generally always looked at military bases. What difference does it make? Yes, it's inconvenient to get it back from Alaska, but if that's what we ended up doing, why are you nervous about it? I never could get a satisfactory answer to that, but it, again, never had to be finally dealt with, because Vandenberg went away after *Challenger*. But it was an ongoing thing and continued throughout the whole time we were dealing with the Air Force.

In a day-to-day sense, one of the things that we had was a Program Requirements Control Board. It was more than a Configuration Control Board. The Level Two program had a set of what they called volumes, which were, in effect, specs for different aspects—hardware specs, launch and landing specs, ops specs, payload specs, and so on. So there was a lot of governing requirements or governing specifications, and they were called the program requirements, but they had requirements like you can't change anything that affects form, fit or function, you know, at certain points. So if somebody wanted to do that, then it had to come back in.

There were ground rules, too, for what authority the Level Three projects had to make changes. In many cases they didn't have as much authority perhaps as they should have, but, nevertheless, they did. So this was an institution by the time I got there. Hundreds of people made these pilgrimages to Room 602 in Building 1, where they presented their case for whatever it is they wanted to do to change these set of specifications that we had in the program. It generally got to be a one-day-a-week, eight or ten hours, dark room, viewgraphs,

listening to the dronings-on, trying to extract from some engineers what in the hell they were trying to tell me. Some guys are very good at it, some people are not very clear. They know that they have a story and they want to tell you something, but they don't always articulate it too well. So they were always the amusing ones.

As a matter of fact, years later, people commented to me—I just pass this out for today—that they were always amazed at the patience that I exhibited, but I never did feel terribly patient about it. [Laughter] So I did that probably once a week. It was an all-day event. It was very rigorous.

Burt [F.] Jackson was the guy who ran the configuration control system for Level Two. He was somewhat hated by all the projects because he documented every action we gave them and insisted that they get it done. On the other hand, he performed a great service for the program in keeping it rigorous, under control, traceable. You could go back and look two years ago or five years ago and see what was decided. It was a very good system. But it was tedious. Even reading the directives which would be the result of the discussion, the conclusions, that was an art form in itself because it had all this nomenclature and different terms meant different things. So it took me a while to catch on to what it is this thing was I was sitting on top of.

There were a lot of other meetings, kind of a rolling set of meetings having to do with technical subjects, program subjects, manifest, budgets, and on and on. As a matter of fact, when I look back on it, it's almost a blur. I look back on the flights that I was involved in as a Shuttle program manager and they're like little high points. Most of the time it's just this stuff that goes on in handling all the day-to-day traffic. I always tried to diminish the traffic that had to come to me, but there were a lot of times valid reasons why the specs had to be so and so. So it was a difficult system, but everybody had to learn to live with it, and it was workable.

We did a lot of traveling to other centers, to the contractors, to the Cape, of course, but a blur. As a matter of fact, when I got out of the job in '85, I didn't realize how tired I was until I got out of it, physically tired, maybe mentally tired. Because I was just involved in it and adrenaline would go every day and you're involved in all this stuff. But after a while, it wears you down. There were a number of positions that now exist in the system that didn't even exist there, so I was kind of doing a number of these things and never even thought about it very much.

Besides, attendant to the Level Two program job, there were other things that have now been institutionalized that weren't at that time, that I had also done. So it was a lot of stuff. Then, of course, the intensity of it all in terms of trying to be sure that you haven't made any mistakes, haven't made any misses, haven't made errors, and that you could keep your finger on the safety of what was going on. So that was what it was like.

I'll tell you a story about the budget stuff. There was a thing called APA, which was something Program Adjustment. It was, in effect, the administering of reserve monies to solve problems. Well, people have gotten this idea in their head that despite the fact that each program might have two or three, four thousand people working on it, that if they had to make a modification or fix a problem, that it always would require more money so that they would come to the program for reserve. This is a natural thing that occurs in the programs, and almost anything you do, someone keeps a kitty of money.

Well, I never had any money, because every budget exercise that we did while I was in office, the program requirements for the year we were in were always 400 million dollars, about 10 percent or thereabouts, over the monies available. So, you know, we never had money, enough money in accordance with what people said it would cost. So we spent every budget cycle. We must have done those three, four, five times a year, scrambling around, shaving this off, shaving that down, blah, blah, blah. But still, even within those budgets, people had in each individual project fairly large staffs of people working on it.

So anyway, they had this thing about how whenever I asked them to do something, they wanted to get reserve, and I didn't have any. So I struggled with that for a while. There wasn't any extra money in the program. We were oversubscribed by 10 percent every year. So then I started to say, "Well, fine, if that's what you want." So I used to keep books on how much reserve. I would approve this change and then I would allocate so much reserve money to these guys, and we would keep books on this project got 50 million dollars this year and this project got an extra 50 million, and so on, and it was very rigorous, but we never put any more money in the system, because the money, of course, is controlled by a controller in Washington who wanted to be sure that we could live—they could not take contract actions or do things that would go beyond the amount of money that he had. It's against the law.

So the flow of budget money to them was such that they stayed within their original budgets. You can't spend any more than the Congress appropriates. But we had this set of books on the side that always made them think that I was giving them some reserve. I don't know, they must have known what I was doing. But it seemed to make everybody happy. It was completely artificial. [Laughter] But it got people over the hump of, "I can't do any more work," because my attitude always was, "Look. You've got 3,000 people out there. You can do this thing. Just do it. Have them do this rather than whatever the hell else they were doing." And that's not entirely fair and so on, but, nevertheless, it worked. It was surprising to me. We did this for a couple of years, kept track of all the stuff and how much APA we'd allocate. There was never any money. [Laughter] They never got any more money than the original budget. So it worked.

BUTLER: Whatever it takes.

LUNNEY: So there was one part about that I still to this day am somewhat disappointed in, and that is that one of the places where it's sort of last to get money was the spares budget, primarily the spares budget for the orbiter. The guys who worked on it were very good and everything, but they were a little bit inarticulate about how much money they needed and why.

So it was very hard to get a defensible case for spares from them. I knew we needed them. Everybody knew we needed them, but they didn't do a very good job of justifying, so they always tended to get short shrift in the longer-range budget planning exercises. So when the year came in which you had money and you were executing, they generally were kind of last kid at the table in terms of how much they were going to get out of the dinner.

I'm disappointed that we never really rectified that very well during my tenure. Generally the orbiter's spares budget was constrained severely. We didn't have enough money to buy the spares we needed. There was a fair amount of cannibalization going on, which means if we needed a radio or a part, we went to the other orbiter and brought it over here and so on. And that's not a very good way to operate, because it disrupts both flows.

But it was the way it was, and I look back and I feel a little bit bad about that, but at the time we didn't think we had any more money than that what we had, and we thought we had it allocated about right in the spares budget. We didn't really get enough money to be adequate, let alone robust in terms of what they would have in capability.

So let me stop there for a just a minute and we'll go to the flights. How am I doing on time?

BUTLER: Doing pretty good.

LUNNEY: I'll talk about the flights and some of that.

BUTLER: Great.

LUNNEY: I feel like I'm telling you more than you ever wanted to know about a lot of things. Like this thing they had about the cross-range and performance, I never could understand what the hell they were trying to accomplish.

RUSNAK: That's something I've been looking into a lot, to try to figure out where the cross-range came from.

LUNNEY: Really? Well, can you figure it out?

RUSNAK: The general idea is, like you said—

LUNNEY: Get back to Vandenberg.

RUSNAK: Right. To get back to Vandenberg, because that's how much the Earth rotates after one thing. But, of course, underlying that is the types of missions they need to do that in a singular orbit.

LUNNEY: Right.

RUSNAK: Of course, this goes back to the Shuttle design, why we end up with a delta-wing orbiter versus a straight wing.

LUNNEY: But we started to introduce different landing fields that were further west. Boy, that just really upset them. They weren't very practical. I mean, landing in Alaska is not

very practical, but that's the kind of thing we were exploring to find some way out of it, because I don't think we could have flown that far, that kind of cross-range. I don't think we could have made it.

So that was some of the background on sort of the environment and the interfaces and some of the players that were around at the time, and the little bit of my time was like, and I said this, but it's probably worth repeating. Looking back on it, it does a little bit of a blur feeling to it, or something where you're going about two or three times the speed that you should be. There were so many different kinds of things going on, because by the time we flew, we still were a long way away from a spec vehicle in terms of the performance of it. For example, the engines, we weren't able to run those at full power, and so on and so on.

So there were so many things that were just not quite at spec level. They were okay and we could live with them and fly with them within certain constraints, but there were many things that we just hadn't finished yet, and we certainly didn't have the robustness to the system in terms of having a lot of spare parts and a lot of extra gear around, so that if we needed to do something we could.

So it we were always straining against the constraints of the hardware and the availability of the equipment and so on, and it just felt that way. So there was just sort of a nonstop one problem after another feeling to it. The PRCB meetings were like all-day events, and there were so many other kinds of meetings like that. There were trips to Washington and to the other centers to talk about things. It just kind of blurred on by.

I talked some about the fact that Kraft left NASA in '82. That was a real blow to me personally, because he'd been such a leader that I'd looked up to for so many years and he had contributed so much to the program. I often wonder what the program would have been like had that not happened, or what the current days would be like if that had not happened, current time. Things probably would have been some different than they are today. But I

guess those sorts of things happen in all avenues, and it was one of those things. We just weren't used to experiencing that kind of thing, and it was a blow, a blow to us.

Okay, well, let's see. Let me talk about some of the flights now, some of the things I can remember about that. STS-1 got off in April, it had a glitch or two with the general-purpose computers timing thing, but they got that fixed and got it off. It was a fairly successful flight. I mean, it was a completely successful flight. But there were a couple of things that occurred that then caused us to reinforce some efforts afterwards.

The flight was flown, and soon thereafter Bob Thompson opted out and Chris asked me to do the Level Two Space Shuttle program office job, which I was happy to do. We consolidated the office that I came from into the Shuttle office, so everything got together and it was fine.

But we had interesting thing. When STS-1 flew, the guys [John W. Young and Robert L. Crippen] got in orbit, opened the cargo bay doors, looked out the window, and noticed a big black hole back on one of the pods where something had not—or the tiles had fallen, or whatever, off the pods. And that was a likely target because if ice formed on the top of the little external tank on the ground, where, by the way, there's some exhaust venting going on and it gets cold. We put heated nitrogen in there to keep that from happening. But nevertheless, if you could get some ice up there, it could come tumbling back over the wing of the orbiter and would hit the OMS [Orbital Maneuvering System] pod, which is up on the back end by the tail. Lo and behold, you'd open the doors, look back, and there's this big black spot looking at you.

So one of my first assignments—I don't want to call it an assignment. One my first priorities when I got on there was, okay, how did this damage happen and despite all that we've done, how can we keep it from happening again? Because there was a lot of attention had been paid in the design. This little beany cap is designed to prevent ice from forming up there and so on, on the external tank, but we still had it nevertheless. So we had a round of

extra duties on how do we keep this from happening, and also how do we make the tiles or the thermal protection on the OMS pod tougher. So that if all else fails and we do have some ice and it falls down and hits the thing, how do we keep it from falling off like this couple of tiles did?

We had some different material. I don't know if it was different material or different densities, but whatever, we did build some tougher tiles for that application on the OMS pod and gradually got that put on all the OMS pods.

Now, the other thing that happened on STS-1, which was not visible but which was obvious when people went and looked at the data was that the vehicle sits on the pad with the two SRBs over these holes that go down through the launch pad and it goes out. Well, apparently, some of the pressure wave that goes down into the hole reflected back out of the hole and affected the loading of the aft end of the orbiter wing surprisingly highly, more than you would have expected. It's a little bit like we were shooting these big shockwaves from the SRB down into the hole on the assumption that it wouldn't come out. In this case, some of it was bouncing back out, the energy was bouncing back out and putting a load on the wings, the ailerons on the orbiter.

So Max, you know genius that he is, and everybody has all these crazy ideas, but Max has another crazy idea that works, he just gets these plastic bags like hot dogs—by the way, the holes are like, I don't know, twenty or thirty feet big. It's a big hole. He fills them with water and then we string them like little sausages all the way across the hole, but with enough room for the exhaust to go down in. So the theory is, in Glynn's view of it, we're going to take this pressure wave and stick it down the hole, then we put these water bags on top so it that it can't get back up, which is about what we were doing.

I'm sure there's a more technical explanation than that for it, but that's about what we decided, and the bloody thing worked fine. I think they're still using the water bags today,

and nobody ever talks about it. It's just part of the pad, but it's a way to keep the pressure wave down in the hole.

So we spent a fair bit of time working on that. That was the immediate problems that came out of the flight, and there was always some immediate problems, but then all of the rest of the issues associated with getting the orbiter and the plan and the flights and so on and so on. Then we began to think about the next flight, and at the time somewhere in there it was decided that we would have four flights. It may have already been decided by the time we got there, I can't remember, and we would have ejection seats, so we had two crew members.

Now, on the next flight, in terms of getting ready for STS-2, we did have a scrub for the APU, and, by the way, that was what was in flight November of '81. That was why this argument occurred with Chris and the senior management in Washington, which I think had something to do with the environment surrounding his continuation as center director. As I talked about before, that ended up changing in August of '82, about a year later, not quite a year later, ten months later, maybe.

But we did have this problem. We scrubbed, and it was a valid scrub, and I think people had figured out the problem right and we fixed it and went on from there. STS-2 got launched with Joe Engle and Dick [Richard H.] Truly. That was an interesting flight. Number one, we were chagrined at the difficulty—not the difficulty, there was a little bit of difficulty arriving at a decision about the scrub of the APU, because it was done with some of this insight from Washington and they were kind of in the loop and asking questions and so on and so on, and it made it less crisp than we were used to dealing with.

It was like having all this advice and counsel and questioning along the side, and generally by people who, although good, were not aware of how any of these systems worked. I mean, they'd never even seen them or experienced them or looked at the designs, or whatever, but they had opinions. So we were kind of annoyed with that—"chagrined"

may be a better term—and kind of resolved that we would try to find a better way of dealing with problems like that when they happened again, so that we would know amongst ourselves where we stood, rather than have us get kind of pulled and jerked in open discussion.

During the flight of STS-2, one of the fuel cells went bad and had to be shut down. So we had three fuel cells, one was bad. And the question was faced with, well, shall we stay up or shall we come down? I argued for—we rounded up the key players, we went to breakfast together over at the cafeteria, we talked it out and said my argument and one that a lot of other people had, too, a number of other people had, were, "Look. We've accomplished most of what we went up there for. We got one out, we don't know exactly why it went out. Maybe it'll affect the other ones we've got." We were kind of early there in our experience there, second flight, so we didn't have a good idea that maybe we weren't seeing a problem that was going to occur in each one of them. "We got most of all we went there for. Why don't we pack it up and get these guys home, and get this understood and fixed and get on with the next flight."

We decided that, kind of, with the regular folks who had decided these things together for years and years and years without any stuff, and we just kind of announced that was our decision, that's what we're going to do. And that helped some, by the way.

We had this recurring thing over the years of people wanting to inject themselves in the flight decisions, and it doesn't work very well. It's fine to have a review in a room when you're not in an operational setting, because you can debate it and so on and so on, but when you get into a situation where you're trying to decide things, it's very difficult to go back to square one with people who haven't been in the business or experienced with judging the risk that's entailed or the options for minimizing that risk, or at least managing that risk.

So it just requires too much other discussion, because by the time in our careers at this point, we're all very shorthand with each other. I mean, it didn't take a lot of discussion

to illuminate all the pros and cons, the options, and so on, and what the logic would be for a decision, because we'd been doing it for twenty-some years together. So it was not a new thing and it was easy to do with the group of people who'd been doing the same thing, and it was difficult to do if you had a lot of external people messing around with it. So we did it with the guys who knew how to do it, and stuck with that.

It was interesting to go beyond that. That was decided, so we started the preps for entry. Now, we on the ground were really not aware of what was going on with the crew members, because it turns out that although things were going reasonably well, except for this fuel cell, the workload on them was very high. They hardly got any sleep in a 48-hour, or whatever it was, two-day flight. They hardly got any sleep at all. Dick had gotten some anti-motion stuff that he put behind his ears or something, and he'd gotten some of it in his eyes, so he was having trouble seeing. And the timeline for getting them down, to bring it down at the landing site, got to be such they didn't even have time to do the checks the way they wanted, and they didn't even have time to get their helmets on, or at least one of the two didn't have time to get on, maybe both.

But afterwards all this came out in the debriefing, but it was again clear, and this has happened to us a number of times in the past where the people on the ground are not aware of some workload difficulties that the crew airborne is having, and unless you're very intuitive, and we didn't have any basis for thinking that at this time, or unless the crew says so, it's hard to recognize it and then calibrate that workload difficulty into the decisions and the timeline that you're trying to set up, decisions which reflect the timeline. So from the crew point of view, we were rushing them into the orbit and entry. From our point of view, we thought it was fairly nominal in terms of the timeline and not anything out of the ordinary.

The interesting thing about it is, in looking back on it, we had a fairly complex vehicle for people, maybe related to people who have other experiences, if someone gets a new boat, a fairly big power boat or a big sailboat or something, and you're trying to operate

it, when you're first trying to do that, you realize that it takes quite a few hands to get everything taken care of. And we were limited in the number of hands that we had for this particular ship because we had the ejection seats in. The ejection seats were put in as a safety precaution. But in a way they introduced their own unsafety, unsafe condition, because the fact you only had two hands, two people, four hands, limited the amount of things that the crew could do to keep themselves. Then when the time got compressed, that showed up as being the difficulty for them, beyond what we anticipated and beyond what we were aware of in real time.

I mean, it only came out later in the debriefings that how badly rushed the crew was and how poorly they had taken advantage of any sleep opportunities, and they were tired and behind the power curve. The shame of it is, had we known all that really clearly, we probably would have chosen to delay a day and fly three days rather than two, not take too much more risk, but not get ourselves in a position where the crew was worn out. So, again, we learned a lesson that we had learned a number of times in the past and relearned it.

Let's see. Somewhere in here, and I think it might have been between the second and the third flight, the third flight flew in March of '82, so it would have been the winter. It might have been the third flight. The third flight was characterized by a couple of things. One, this Edwards Air Force Base, that I had always been led to believe was such a wonderful landing spot, never had any trouble at all, it rained a lot out there and the lake bed was unusable for long periods of time, for weeks or months at a time, in this case, at least.

So we had to plan this flight in such a way as to move all the landing equipment that we could convoy with trucks and gear that we sent to the landing site. We had to move it all to White Sands [Test Facility] in New Mexico. This has been a landing field, a designated landing field for us, but we never thought much about actually using it. But Edwards was unusable. The crew wasn't ready, we weren't ready, the program wasn't ready to land at

Kennedy yet, on the runway down there, so we didn't have much choice. And we had a fairly major logistics operation of moving all this equipment, all these people and everything.

By the way, there's not a hell of a lot at White Sands. It's not like you had a whole strip like you do at Cocoa Beach with motels and all that. There's some there, a long way away. So the White Sands operation was quite a bit more spartan in many respects than what we had.

And it might have been this flight, also, but in the preparation for it, I and a number of the guys that worked for me would show up at the Cape, the Marshall project engineers, the orbiter project engineers, show up a couple of days before launch for the flight readiness final tag-up and then for the countdown start. Well, the night or two before we were scheduled to launch this thing, we had a hail storm. In Florida, a hail storm. It pockmarked a tank, it pockmarked the orbiter tiles. I remember going out there, because we were there, and I went out on the pad and looking, "Holy God, look at this thing." You know, it looked like it had measles all over it, and chunks taken out of it. It was a mess.

To harken back to some comments I made before about the Cape team, I mean, before you knew it, they were scaffolding all around this thing. The pad's a difficult place to work. It's fine when you had planned access, something that they had planned for. But just to get up anywhere on the tank or anywhere on the orbiter is difficult, because it's very large stuff sticking way up in the air and there's platforms around it. You can't get them around it.

So anyway, these guys rigged up all this scaffolding and climbed all over this thing and fixed them. They fixed them well enough so that we could launch. I think they did it like in a twenty-four-hour period. It might have been forty-eight, but they fixed it in a relatively short period of time. I mean, it was an amazing performance on the part of the team down there.

Of course, the engineering team had to be involved because they had to help them with how do you fix it, and is the fix adequate. So we had to continue to be satisfied that you

can't just throw some putty at it and walk away, but that the fix what actually would be good. But they did it. I think that was the same flight that we ended up launching where we went to Northrop.

On the first landing attempt at Northrop, this is when that I found myself trapped in the position of dealing with the weather and whether it was good enough to land. The weather was pretty bad on our first landing opportunity, bad in terms of wind. It was blowing very hard. We hadn't institutionalized data or system or television or anything to help me understand that, because it was kind of a last order of priority thing that I did. But it was that experience, I think, that led to us institutionalizing a much better treatment of the weather and put it into the control center at the Cape, but in this case the control in Houston, so that people could deal with it. It worked a lot better, and I was happy to get out.

Though we waived off one day, we landed there and the landing went fine and all that, but it was tedious as White Sands' name, because it's white, it's like gypsum, maybe some salt in it, too. Or maybe that's what gypsum is. But anyway, it's this very fine white powder and it blows all over the place, and we were plagued with it for a while in terms of getting in the thrusters and all these little tiny places where the thruster has to work and the orifices. So I didn't want to go back there again. Although other people thought it was still a great place to land, I didn't want to take an orbiter back there.

STS-4, this landed on July 4th, I think, of '82. I remember Ronald [W.] Reagan was out at the landing site at Edwards. Ken [Thomas K.] Mattingly [II] flew. In the debriefings, Ken kind of put a worry in all of our minds that ended up not really transpiring very much for other people, but he talked about how when he was concentrating on the landing he felt increasingly like he was in a tunnel, in terms of seeing the landing scene and responses. I didn't know how much to worry about that. It was the first time we had a report like that. But sometimes Ken over-interpreted things, and maybe he was doing that in this case, or maybe it was just actually the way he felt. But it kind of gave us a scare for a while as to

what the crew was going to experience when they came in for a landing. We didn't know whether it was some adaptation to 1-G effect or whatever that was causing them to have this tunnel feeling, different apparently than what he had in airplanes and in flying the Shuttle training aircraft, or he wouldn't have commented on it.

That kind of left us kind of—I didn't know what to do about it, but we were worried about it. By the way, it reinforced the idea that we didn't want to go land at Kennedy too quickly, we liked this great big desert, even though sometimes it was wet.

We also lost, I think, the SRBs on that flight, parachute problem, one or both SRBs, I can't remember. So we had to do parachute mods to get that fixed.

Let's see, by that time, interestingly enough, the Fourth of July in '82, it was the fourth OFT flight and it was over and we were looking forward to moving onto operations per se, and got ready for the first one of those, which was a couple of comsats on STS-5 that we flew in November, I think, of '82.

At that time we had this idea, as I told you, on the front end about moving from the development phase to operations or becoming operational and we were somewhat celebrating that transition, although I think it was more of a slogan than it was reality, because we continued to do things with a very heavy carryover of what had to be the discipline and the engineering support that we had for the development flights. It hardly changed, but we put a different label on it, but it went on pretty much as before.

Let's see. STS-6 was an interesting flight in a couple of ways. Number one, it was a new vehicle, and we had introduced the idea of a flight-readiness firing with the new vehicle. The orbiter has a lot of plumbing inside it where you flow the propellants down to the engines and, of course, the connector and power of the ship in addition to the SRBs. But the whole thing, that orbiter coupled with the tank doesn't get put together in a factory, and we certainly don't flow any propellants like that. We had done that in test vehicles sometime ago, but not this orbiter.

So we're always concerned that there might be some singular thing in a new orbiter that was different from the other orbiters that might create a problem. So we invented this idea of Flight Readiness Firings [FRF], where a new orbiter would go through a firing on the pad, where we'd we actually light the engines for a while and let the vehicle stabilize and then shut them down.

Well, we did one of those, and then we had a leak in the engine. It was a hydrogen leak. We thought we fixed it and then we did another one, and we had more leaks. So we were chasing this hydrogen leak in the engine compartment or in the engines, I can't remember how long, but it seemed like we chased it for a month or two. Let me see. We finally flew—when did we finally fly STS-6? We flew it in April, so we had these FRFs like in January, first of the year.

So we struggled with it for about three months in terms of we had to change out engines and check plumbing, plumbing in the orbiter and so on. I can't remember everything that we did, but we began to get the feeling, are we ever going to get this thing ready to launch, because we couldn't fly it that way and we couldn't exactly pin down what the problem was. We eventually changed out enough hardware where we got it checked out and it worked, and we went on and then it worked fine when we got there. But it was not easy to do. So that was the first flight of *Challenger*, and the engine leaks were a plague, probably three months it cost us fooling around with those things.

We had a payload in the cargo bay that was the tracking and data relay satellite. It was the first one of those that was going up to establish the satellite network that NASA was going to use, and it was boosted up to geosynchronous altitude by an Interim Upper Stage vehicle that the Air Force was building. The Interim Upper Stage actually had two stages.

The Shuttle orbit, let's talk about it in simple terms, was like at about 150 miles, and we had to take this thing and go up to 22,000 miles above the Earth in a circular orbit. So the first stage would take it up to the 22,000 miles, but part of the orbit would still be down at

150. Then the second stage would kick it, once it got up there, so that the orbit would then round out as a circle, circular orbit above the Earth, 22,000 miles where it would be stationary.

Well, first flight of the IUS, I think, first flight of tracking and data relay, first flight of this new vehicle called *Challenger*, and it went off, the first stage went okay. So we were in this 22,000 miles up here and 150 down here in the second stage fired, the Interim Upper Stage, second vehicle on the second stage. It fired and something went wrong. I don't remember the failure investigation in terms of exactly what it was, but the vehicle seemed to lose control somehow at some point, so that we lost contact with the vehicle completely.

There was some sort of a timing sequence because the separation of the tracking and data relay satellite from the last stage of the IUS was powered by batteries that were in the IUS itself. They were starting—I can't remember the exact details, but there was a clock running that said, if you don't do something, you're not going to be able to get this thing separated in a certain period of time. So we didn't have any communications with the vehicle. One of the guys identified this constraint that said, even if we don't have any communications and even if this thing is lost, if it's still working someplace where we can't find it, we've got to get off this stage.

So we started to transmit separation commands in the blind not knowing, not having any communications with the vehicle, and we jacked up the power on the network to as high as we could get and we were radiating these commands to get off the stage and so on and so on. We never got any signal. So I don't know exactly what the time is, the records would show, but we went through that.

Leonard and the guys were working the problem with the Air Force team that was out in Sunnyvale, [California] IUS team and so on, and the network, and trying all we could do to get communications. It dragged on for probably—I remember this happened, the deployment happened probably in the evening or at night, and by the next morning around

breakfast time we were getting ready to just give up on it, when the network picked up a signal from the tracking data relay satellite.

As luck would have it, that particular vehicle had a lot more fuel on board than the next vehicles would have, because there was some equipment that they were intending to put on them that hadn't made it for the first flight. So they filled up the tanks and they had a lot of propellant on board the tracking and data relay satellite, and they had very, very small thrusters. So now we were in an orbit that was about 22,000 miles above the Earth on one side and about halfway to the 22,000, eleven or ten or 12,000 on the other side.

Over a period of several months they just used these little bitty thrusters for some minutes or tenths of minutes, however long they could burn those things, and they gradually upped the orbit so that—I don't know if it ever got to exactly the right orbit. I think it got to it, but I'm not sure of that, but it got to a very useable orbit, so that NASA could use the tracking data relay satellite and it wasn't completely lost.

So it turned out to be a long night for us and something that we thought again with two first, that we were dealing with, IUS and the tracking data relay satellite, that we'd lost them both. But it turns out that although the IUS had to be analyzed and then fixed, lo and behold, the tracking data relay to some degree was recoverable.

So anyway, that was our debut with *Challenger* on STS-6. It was an exciting time all around, very exciting time all around, but we finally got through it all and we were back on track.

STS-7 was another flight. Crippen was back commanding it. As a matter of fact, I think Crippen commanded about four flights, several of them very close together. Bob is an exceptionally able astronaut, but also an exceptionally able leader of people, and I think George Abbey at the time wanted to use Crip as much as he could to help train and pass on what he could to the new crews, many of whom were rookies to spaceflight. So Crippen had a lot of duty in terms of flights. I think he flew four times, starting with the first one and then

this one and then a couple more in the first four years of operations while I was the program manager.

So anyway, couple of comsats and then we had a little platform that we called SPAS [Shuttle Pallet Satellite], which stands for something I can't remember, but it was a little experiment platform we put over the side and they used the manipulator to put it over and then to back away from it, rerendezvous with it, pick it back up after a while, a day or two. Generally a pretty smooth flight. Sally Ride's first flight.

We were starting to feel kind of comfortable that we knew how to handle the communication satellite traffic in terms of what we had to do to get them ready, what we had to do to put them in there, what the crews had to do, the procedures and so on. The stuff worked pretty well, and 7 worked well all around.

As a matter of fact, one of the popular photos of 7 has the arm in the shape of a seven. Not everybody recognizes that, but I do, and whenever I see it, I can see a little seven there. That was a little trick that the crew worked up somewhere in their inventive factory over there and came up with. Because SPAS had a camera on it. SPAS was taking pictures. It was the first time we had pictures of the orbiter by something else. Beautiful photos of the orbiter that way.

Well, let's see, STS-8 was in August of '83. Dick Truly was flying, and because of the unique requirements of the INSAT satellite that we had just for the country of India, we had to launch at night to do it, launch and land at night. Generally, it landed about the same time as when you launch, so even if we're several days later it'd still be nighttime. As a matter of fact, it was sort of the middle of the night, as I recall. I don't remember the exact time, it was 1 or 2 AM It was a scheduled launch.

Well, anyway, I was down in the launch control center again, and I think by this time I still hadn't completely delegated this weather bug that I had picked up. So we're down here and we got these lightening and thunder storms all around the Cape, flashing all over the

Cape, big. I have a picture on my wall at home that Dick Truly signed for me, a picture of the orbiter on the stack out there, and these lightening bolts jamming down. Oh, it was awful just watching it. It was just frightening. It was one of those displays where it just keeps going on and on and on.

Crip was the weather pilot, as a matter of fact. He was up flying in the T-30, or maybe the STA, Shuttle Training Aircraft, for the weather, because Truly's inscription to me is, he says, "Glynn, thanks for," blah, blah, blah. But he says, "This is what you get when Crip is the weather guy." [Laughter]

But sometime before the scheduled launch, it sort of cleared off and all of the radar, weather radar, tracking and all the meteorologists, they were all okay. So I'm sitting around here saying, "Well, what are we going to do? Wait till tomorrow? It's all cleared off. It's okay. There's no real sensitivity to triggering something airborne." So we launched. But it was a raging night when we went there for the countdown. The launch went fine and that flight went fine. It landed, I guess, at Edwards in the dark, but that went fine, too. That was STS-8 into the books.

STS-9 was John Young on the first flight of the Spacelab. This is the European-developed Spacelab and it had a big pressurized compartment in the cargo bay, lots of experiments on it. I think it was delayed, too, because by that time we were beginning to experience some SRB nozzle problems. I think we had to actually go back and replace the nozzle. I think we had to haul the stack back and replace the nozzle on the SRB. I can't remember exactly what the details were, but I remember we had to do something like that.

But at any rate, John, and Brewster [H. Shaw, Jr.] flew, I don't know, several people on the crew, probably six or seven with a mixed crew, including European, I think, at the time, and we ran this Spacelab thing for twenty-four hours a day, probably on two shifts, and it all went fine. The Spacelab hardware, I mean, first time out for it, too, for the Europeans and it worked fine.

The only untoward event I can recall is that we had some leakage from the APU, some leaks from the APU, the fuel hydrazine or something, it was the fuel. We had some fire, actually, in the back end of the orbiter during the landing phase. I can't remember how aware we were at the time, I mean, during the landing phase itself, but it was apparent afterwards that we had some burning back there in the back end. So we had to fix all that.

Then for reasons that I wouldn't want to try to justify, we stopped counting flights by number and we went to this other technique, which was interesting. It had to do with the year, the last digit of the year, which launch site we were on, and then the ABCs were each flight and launch site. So it was fairly—but, you know, it's still to this day we don't seem to be able to count the flights very well. That's because in the planning for a flight, a flight number gets a certain identity in terms of all the things that are on it and the crew and different uniqueness of it, and then other flights with other designators have their own character developed, and then sometimes they get swapped around, so we're out of order.

Anyway, the next flight got ready to go and it was two communication satellites, WESTAR, which was an American group, and PALAPA, which was for the country of Indonesia. I believe I talked about this some when I was doing the payload discussion. We, over the course of the years dealing with people, began to appreciate the fact that we never could fully understand the basis they might have for making a decision. They had insurance coverage, so that made it different than just purely a technical discussion. They also might have political constraints, or whatever, on them that we just wouldn't have any idea. This may or may not have been the case of the Indonesians.

But we launched and the first satellite went out, it was the WESTAR, and the burn of the little solid rocket motor called PAM, [Payload] Assist Module, didn't burn very long. It just sort of stopped after a little while. As a matter of fact, the satellite was in an orbit not too far different from the orbit that the Shuttle was in when we launched it. So we sat around and listened to all that, and could guess at a number of things that might have happened, but

could not guess that what the next one was going to do. I would think the odds are that it wouldn't do the same thing. It was my guess.

But here are these little Indonesian guys over here in the corner trying to decide what to do. I think I referred to this in an earlier interview, but I used to try to shield the customer from all the well-intentioned, but overbearing NASA people. I had to go to [Texas] A&M [University] for something, I can't remember what it was, one my kids was involved in something and I had to go to A&M for, for a couple of hours. So as I was leaving, I said, "Now, look," and I was pointing to the Headquarters guys, "I don't want you messing around with these guys over here, the customers. They've got to decide what they want to do and I don't want you over there. If they ask you a question or ask us a question, fine, we have to give them every amount of help we can give them, but in the end this is their decision to make and we don't have a clue as to what their background is for whatever decision they're going to make, only they do."

Well, so I went to A&M and came back, and I'll be darned if our little NASA guys, especially from Washington, didn't feel compelled to advise these guys what they thought should be done, which was not to launch. Well, anyway, the little guys and went and decided—I say "little guys." The people from Indonesia decided—they weren't so short—decided that they should launch because with all that they had on their plate, and all they had in the way of facts and non-facts, that's what they decided to do.

It turned out that whatever the problem was repeated itself, because the next satellite ended up in the same relatively useless but close to the Shuttle orbit as the first one, and that was that. We did some more things on the flight, but there we were stuck with two communication satellites in orbit, and probably before we got down we were thinking about what we might could do to rescue them, although that was a new thought to us, a new thought to rescue satellites.

In planning for Solar Max repair, Solar Max was a satellite that was on orbit that Goddard [Space Flight Center, Greenbelt, Maryland] had built, it was built to be captured and retrieved and reserviced by the Shuttle and the crew, and we had been planning that for some time, so we said, "Well, maybe we can go back and get these things," which we did on a later flight.

Let's see, which one am I on? The next flight was the Solar Max flight, I think, in April of '84. Crippen commanded it again. It was our first attempt at, and we were successful at, satellite retrieval, servicing, and the crew brought it into the cargo bay and all that with it. I would point out that it had been in active planning for about three years. It had actually been thought about and conceived as a satellite that would be designed in such a way as to enable this to happen by Goddard.

There was a man at Goddard, Frank Ceppolino, who was just an absolute advocate for designing Goddard Earth orbit satellites so that they could be retrieved and serviced by a crew in the Shuttle. He was probably one of the few voices in the country, certainly the only voice at his center, that promoted such an idea. Ceppi, by nickname to everybody, and even today I still carry on kind of warm conversations with Ceppi about this or that or the other thing, but he was very much of an advocate, never did meet after this with much success in getting things designed so that they would be retrievable and serviceable, but perhaps a prophet before his time in that more of that would come to pass in the future. But he had designed this satellite so that it was sort of you could remove things and plug new things back in, and it needed that, this satellite.

So we actively began planning it and probably had about a three-year planning cycle for this particular mission that Crip commanded. The capture of it, I think the first attempt at capturing it didn't go well. We couldn't quite get it. I think we had to stumble around for a while, sleep on it, and then the crew got it the next day and repaired it and put it back out and

it worked fine. So it was a real success and a pathfinder, really, in terms of what we were able to do at the time.

I would make a point of the three years, because we subsequently on a later flight went up and captured the WESTAR and the PALAPA satellites and brought them back. We did that in about nine months, as I recall, from the time that they were left in orbit. So we started with this thing that we had planned a lot on in three years, then we did one in nine months.

Then at the end of my tenure as a program manager, we lost the SYNCOM in April or so, maybe May, of '85. Then on the subsequent flight after I left, Joe Engle went back on another flight and repaired it and then it went up to orbit, and we did that in three months.

So what was interesting is we were doing these rescues and reservicing or fixing or whatever you want to call it, whatever was required, and the first one took three years, the second one took nine months, the third one took three months. Which was a little bit of the sense that we had in the program of increasingly being able to execute complicated things in not as long a period of time as we were taking on the front end of the program. So we probably were advancing in more than name or slogan towards the goal of being operational, which is a stretch term for a system of this type. But we did do some things that were compressed and we did them pretty well and we got increasingly better at them.

Let's see. August '84, we had the *Discovery*, 41 Delta [41-D], we had a flight readiness firing, we had an on-pad abort, but we did get launched and we launched a number of the communications satellites. We also were flying the continuous flow of electrophoresis experiment at the time, and Charlie [Charles D.] Walker from McDonnell Douglas [Corporation] was the payload specialist. I think while I was the program manager he probably flew three or so times, almost as many as Crippen, almost as many times as Bob. That was a promising thing that ended up getting sidetracked for other reasons, but I was always kind of disappointed that that didn't get to play out fully to see how that would have

worked, but there were a variety of reasons in the background. Johnson & Johnson was the pharmaceutical company behind that program and behind the initiative to do it.

Let's see. 41-G was another flight. Again, I think, Crip commanded it. I mean, he did the Solar Max, skipped one, and was commanding this one, so it was about the fourth time I saw that sequence. But he was performing a valuable service to the program and to the astronaut corps in terms of getting people on board. They did an EVA refueling. I think Kathy [Kathryn D.] Sullivan went out and did that on that flight. That all went pretty well.

Then we had the rescue flight in November of '84 where we rescued the two. We set out a number of satellites, sent them on their way, and then we took these others and put them back in the little cocoons that we had for these communication satellites, the PAM-D thermal cocoon. I've forgotten what we called it exactly, but the little container that McDonnell Douglas built that allowed us to separate the satellites and keep them thermally balanced. So we got it back, put them back in there and brought them to ground. I think they always had trouble dealing with them afterwards, because they were sort of damaged goods.

Had it been NASA hardware, it probably would have been deployed, but they're actually sort of business hardware, commercial hardware, and they had been insured, and the companies involved, or the country involved, got their receipts from the insurance company. The insurance company then I think owned them and they never could exactly sell it to anybody because they're as expensive as buying a new one, so people would buy a new satellite.

Let's see. January '85, we flew a classified mission for the Department of Defense, cold. We scrubbed it one time, because it was cold. I believe that it was on that flight that we got our first indication of what might have been blow-through in the O-rings for the SRB. Ken Mattingly was the commander of the flight. Of course, we didn't know this until afterwards when people inspected them. But the alarm bells didn't go off. It was generally—at least I received it as being treated by the project as, well, yes, but this was a unique

circumstance and this thing tends to be self-healing, that is, the gap tends to close, so on and so on. At least in my discussion, it was known that there was some indication of a problem, but it was generally in the category of it's sort of self-healing and it's not going to get any worse.

Unfortunately, of course, it did a year later, and unfortunately we were not smart enough to trip to the signal that we were getting on that flight, called 51 Charlie [51-C]. It was cold. We scrubbed it once, I think, because it was cold, but it was cold at that launch attempt.

Later on, we had a flight in April where we had a couple of communication satellites deployed, but it was unique in a number of ways. [E.] Jake Garn, who was Senate appropriations at the time, had been assigned to this flight for sometime. Karol [J.] Bobko, Bo, was the commander of the flight, Don [Donald E.] Williams was his co-pilot. I think Charlie Walker was on the flight, too. But you know how these things go and how they get decided, but, nevertheless, Jake Garn was assigned to this flight. Jake's been a pilot all his life, by the way, and still flies. I think even builds or maintains, I don't know if he builds but he certainly maintains his own airplanes, still flies. He's very active in aviation and was in the state of Utah, which is the state he was representing when he was in the Senate. He's now moved on from there, from the Senate, that is.

But anyway, he was assigned, and that was a new dimension to us. It was funny to go to a meeting, you know, I never knew quite how to refer to him, so I mean, I think I started calling him Senator Jake. [Laughter] But it didn't seem useful to call him Senator Garn, that seemed over—it didn't seem entirely appropriate not to accord him the respect that he was entitled. So I think most of us ended up calling him Senator Jake for most of the time.

He was fun. He was talkative. I mean, he had a tendency to talk, and sometimes he'd talk about things that didn't have anything to do with any of us. It had to do with his experience in Senate, of course, and it was interesting, but it didn't have anything to do with

what we were doing. [Laughter] So that was kind an interesting dimension to the flight and I think he got a lot out of that. He still talks about it. As a matter of fact, I see him off and on even today, and it's still fun.

Now, in the course of that flight, one of the satellites was called LEASAT or SYNCOM. But LEASAT was built for the Navy by Hughes, and it was, again, one of these satellites that was uniquely designed for the Space Shuttle. It was kind of a cylinder that took up the whole cargo bay 15-foot diameter. So it just took up all the space. And the deployment system was one where you just kind of released on one side and pushed with the spring and it flipped over the side. It had a little roll to it, which stabilized the vehicle. The action of releasing it triggered some timers, as some switches were allowed to open or close, as it got pushed away, so that that set the timers in motion for when the solid rocket motor would fire about forty-five minutes later, kick this thing on the way to geosync.

Well, as luck would have it, nothing happened. It didn't kick to geosync; the motor didn't fire. The relatively immediate conclusion we came to and the most likely reason for that was this little switch that should have tripped when we pushed it off, didn't trip, for whatever reason. Sometimes mechanical things will do that on you. We were fairly convinced that if we could just trip it, and it was sticking out a little bit, and we said to trip it, that the timer would start and this thing would go on.

On the ground, we began to envision what it would take to go back. We had some fairly strong arguments about it in this particular flight. There was a previous manifest on this flight, something else, where the crew had trained for rendezvous, so I was fairly comfortable just generically in all the crews, generically in this crew, but also that they had trained for rendezvous. So conceivably they could go rendezvous with this thing, and if there was some way to fix it, we could figure it out.

But I had some contesting going on on the ground, mostly from senior members of the astronaut corps who were—I don't know what. I was having trouble discerning exactly.

One thing, they were worried about getting near this thing, because it potentially had a solid rocket motor that could fire, and that was valid. But given that, my question was, okay, well, what do we have to do to respect that? I had trouble getting them around to being can-do about trying this thing. I was a little disappointed. I had the feeling like trying to help our customer out and get this thing started or resolved was worth talking about and trying to figure out how to do, but I didn't get the same sense of commitment to solving the customer's problem that I had myself and I didn't get that from these guys. So I was a little bit testy on the ground in terms of what to do and whether to do something, whether to try something.

The airborne crew was happy to try to do something. As a matter of fact, what was ultimately derived was the idea of building something, I can't remember if we used this boom, but something that we used called a fly swatter with some openings in it, and the idea was to kind of try to trip this switch while the satellite was still spinning, trip it and pull it, and then that would start the whole sequence. So you'd have to trip it at exactly the right time, too, so the motor would fire when you wanted.

Well, eventually we convinced ourselves that that was the safe thing to do and we went through a whole process of considering all the risks and so on and so on. In the meantime, we were having this argument on the side about whether we were going to do it at all. We went to do that, and the crew, of course, got over there and everything went fine. It's just that the fly swatter trick hadn't been exercised a number of times, had no joy to it. It didn't work. But by doing that, we eliminated that as the likely cause of the problem, which was clearly where we had all jumped, including the contractor who built it, Hughes. We'd all concluded that that was the real problem just because it was such an apparently obvious cause of the problem.

So the failure of the fly swatter technique—and by the way, the guy whose crew had to rig this up, [M.] Rhea Seddon was on the flight, and I can't remember who went out to do the poking, it might have been Rhea. But Bo and Don got it back there fine, and the fact that

it didn't work then took the whole team off that was a failure and maybe into what else might be downstream, which turned out it was.

So that didn't work, and we had some little arguments about it, about whether to do it or not, but it did eliminate one likely cause and therefore got us on the right track for something that we did later.

Then in, I don't know, the end of April or May, we flew Spacelab 3, which turned out, in retrospect, to be the last flight that I was involved in, and it was a fairly benign flight. Spacelab 3 was mostly pallets with pressurized computer module that operated it.

But while that was going on, after the fly swatter flight, and before I left office, which was probably a month or so, Joe Engle and Jay [H.] Greene, Joe Engle of the crew, of the astronaut office, Jay Green as a flight director, showed up and they had this idea about going back to rescue and repair the satellite that we had failed to repair with the fly swatter thing. They had been in communications with Hughes. It was fun to talk with them, because it was kind of like, hmm, it was one of those things we could do. Joe and Jay were both very enthusiastic about it. Joe was creating a little bit of a competition by his face to NASA said, "Well, Hughes is ready to do this," and his face to Hughes was, "Well, NASA's ready to go if you guys can figure out what to do."

And they came to me and they were very open and honest about the whole thing and what they were doing and they said, "We want to pursue this." So one of my last decisions in office was, "Yes, I like it. Why don't you guys go pursue that." This was the rescue that then was later pulled off later in the summer, I think, in August.

In about three months from the time it happened to the time of the—a fairly major fix had to be invented and then built and then put in the satellite so that the rest of the circuitry could be made to work. But Joe, bless his heart, it was fun to watch him, because he was orchestrating this thing, and he had a full flight. He had three, or maybe four, I'm not sure, but he had three satellites to deploy on the flight that he was on and he wanted to add this.

This was the "astronauts love to add things to the flight" syndrome, but he wanted to see if they could fix this thing. By that time we had all become enamored of the idea.

One of my last acts was to kind of—I don't know as I clearly had the authority to approve, but I guess I was like Joe and Jay, we kicked the ball far enough down the street and made everybody believe that everybody else was for it, so that it got difficult for people to just blow us off and say no.

Later on that summer, Joe's team deployed all their primary payloads and did a fairly major fix on the SYNCOM and the LEASAT satellite interchangeable terminology, got it going and went on. But it was fun.

About that time is when I came to the end of my road as the Space Shuttle program manager. I said earlier, and it really occurred to me as I sort of stepped back from it, I didn't realize how much I was wearing out physically and perhaps mentally, but it was quite a load. I never was terribly sensitive to pressure in all the jobs I had inside of NASA. I mean, I don't know why, it was just part of the job, so I never really felt a lot of it, but there was tension to it. It was probably more tension to the program manager's job in that you were dependent on so many other people. It was true in the control center as a flight director, too. And you were dependent on so much hardware to perform.

So I guess when it was over, my wife had been telling me, but I realized when I got out of that job, that it had been a long run and I was really tired, because it's one of those things where you do it all the time, you get phone calls during the evening or morning, so all that happens to you and you don't have time to go exercise or enjoy yourself like you should. So a lot of things started tunneling in for you, and after it was over, I realized that was the case.

I suspect that there hadn't been too many program managers of the Shuttle at least since that have gone more than four years. It's probably about as long a term as people put in. Arnie was, Arnie [Arnold D.] Aldrich, Tommy [W. Holloway], Leonard [Nicholson],

Brewster [Shaw], but I suspect with all of them that it was on the order of three, four years and probably not much longer than that, if at all.

I would have to say that, I mean, it was exciting. I mean, I thought we had brought the system a long way. If you could characterize the improvement in the move towards operational by just this servicing and rescue and servicing the vehicles, we moved from three years to nine months to three months, which was a reasonable measure of the confidence and the capabilities that we had developed and the ability of the whole team of people. I mean, it takes a lot more than astronauts to plan and execute a flight like this, and in the case of some of these things, a great deal of cooperation with the payload community that's outside of our direct control, but, nevertheless, relationships were constructive enough that that was relatively easy to work.

So the system had come a long way, not enough in the way of spares, but the *Challenger* in January of '86 still lie ahead of the program and it's a major setback all around, certainly a terrible loss to those people and families, for the families of all of them. Then things changed fairly dramatically after that. What had been the Shuttle's role as the single-launch vehicle for the country, even though a number of us who were actively involved in it thought that should not be the case, that that was too big a step, ended up swinging back completely the other way, where the Shuttle is now being used primarily to serve as manned spaceflight activities, the Space Station. Most other servicing by the Shuttle is sort of gotten—certainly the DoD comsats went away right away, but even the NASA traffic, other than Space Station, oriented is relatively light in number.

So it's interesting to look back on it all and recognize the various directions that had been put in place and how they changed as circumstances evolved. You can even speculate what might have happened if things had come out differently in some respect or another, but that's all that would be, is speculation.

Today, the Shuttle system is behaving and performing remarkably well. It's become much more well characterized. By that I mean, for example, they recently had a problem with the SRB nozzle—recently, several years ago—and it's just amazing how much people know about how they build the SRB nozzle. I talk about the nozzle, but it's true of almost every other part in the Shuttle system. It's amazing how much people know about it and what they have to do to repeat that for the next one and the next one and the next one. So that the degree of uncertainty, or the degree of difference in how something is built tends to be very, very narrow, so that things tend to get built the same way, the same way, the same way, and therefore their performance and their reliability, you can kind of count on it behaving the same way rather than radically different.

I think over the now almost twenty years of the program, flight program, there's considerably more known about how to characterize the hardware, especially the new hardware as it comes in, and how to deal with the hardware that we have. So this is a considerable amount of stability and maturity built in the system. As a matter of fact, this might be the platform or the level of maturity and stability from which you could make another jump to do something much bigger. If you look back, we were coming to the end of a development program that still had a lot of development yet to do when we were trying to be all things to all people. That was a very, very large step to be taken.

But I'm proud of the system today. I'm proud of the way people continue to pay attention to it and to love it and to operate it well, to operate it safely, operate it successfully. I think that's going to continue.

BUTLER: Talking about the consistency and the maturity and so forth, and then reflecting for our future, there are the follow-on programs that they're looking at for a follow-on to Shuttle. Do you have any thoughts on that or will it be build on this?

LUNNEY: We might. We might build on it. We have a tradition of starting over. [Laughter] But I think there's a lot to be learned from this. I mean, starting with the fact that if you're going to start all over with stuff and make it different, it takes a while for it to settle down and for people to understand what are all the critical things about it that you need to keep under control, so that they're all in the middle of this narrow range where they always are repeatable and they behave the way you want them to behave. A new vehicle, a new system, will involve that years of learning again.

The difficulty we have with these rocket propulsion systems is we don't get much time on them as full-up operating systems. I mean, the launches take eight minutes, right, and we get however many we get a year, eight. So we get an hour's worth of system operation a year. If you compare that to aviation, for example, I mean, look at the time you get with jet engines in airplanes with fuel control systems, etc. I mean, it's just astronomical experience. That's the way the aviation industry has improved just by continuing to experiment, fly and prove and so on.

But the test time, the experience time that we have with these propulsion systems, primarily I think that that still is the risk, getting up to orbit. The propulsion system for that eight minutes is pretty minuscule compared to what you can get with most other aviation kinds of systems. Very, very short.

It's that experience that helps people figure out what they need to do to keep all the parameters in some tight zone so it's very repeatable. It's hard to get in rocket business enough experience base to feel like you've covered them all. Things continue to occur that some unique combination of stuff causes a sequence of events that a slightly different combination didn't cause before. So it's part of that learning process.

But in this business, given the nature of what you're doing, which is releasing an explosion and trying to contain it in a constructive way, and the explosion is looking for a way to get out the whole time in an unconstructive way, to get out of there, so it's difficult.

It's technically difficult, and especially at the experience levels in terms of time on the system that we are able to accumulate. It's a long time to get an experience base to get comfortable. As a matter of fact, you never do get comfortable.

So that was my time as a Shuttle Program manager. I have to say I enjoyed it immensely. I mean, number one, it went by too fast. Number two, it went by in a bit of a blur. I mean, I could have taken any three months and made it three years and savored it more than I did. I loved the people that I worked with. I mean, they were all professional, constructive, helpful, can-do kind of people. I thought NASA had a good system, management system, sometimes a little clunky, you know, more than you would like to have, but overall it served NASA well most of the time.

Exciting time. I just relish the fact that I had the opportunity to be there in that window when we went from the first flight to the beginnings, perhaps, of what you might begin to say is the place where we can start calling ourselves or thinking of ourselves as striving to be operational. But a great time, a great time. A tiring time. I have sympathy for the guys who do it, in the sense that I know they're wearing out, even if they don't realize it. So I try always to be helpful to folks that are continuing to do that, and there's a new one every couple of years or four years doing that. I'll continue to do that as long as I can give them any help, if nothing more than just support.

But I loved it. It's wonderful stuff. I loved everything about it. Loved all the people. It's great stuff.

BUTLER: You certainly got a lot of good stuff accomplished. Well, then you went on to work for Rockwell at the time, and I don't know if you want to go on and talk about that a little bit.

LUNNEY: Is that part of this?

BUTLER: Well, if you're interested, we would like to talk a little bit through what you did after NASA.

LUNNEY: Okay.

BUTLER: But that's totally up to you.

LUNNEY: Well, we can do that the next time.

BUTLER: Okay.

[End of Interview]