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CHARLES R. LEWIS
INTERVIEWED BY JENNIFER ROSS-NAZZAL
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ROSS-NAZZAL: Today is July 6th, 2022. This interview with Chuck Lewis is being conducted for the JSC Oral History Project in Houston, Texas. The interviewer is Jennifer Ross-Nazzal. Thank you again. You were selected as a flight director for STS-1 in 1978, which was about three years before we ended up launching the Space Shuttle, so would you talk about that selection and how that came about and what you anticipated working on until that launch?

LEWIS: Yes. The selection was made three years before we actually launched, part of that was slippage in the program. I don't remember exactly when the astronaut class of '78 came on board. They could get some training and then hopefully we'd get the simulators and more training capability. George [W.S.] Abbey assigned each of them to different functions or Shuttle systems to be their Astronaut Office representative. For example, Sally [K.] Ride was assigned to the remote manipulator system. Later she was my CapCom [capsule communicator] on STS-2. We got to meet them, working in some of those interfaces, so that was helpful.

But primarily it was to identify three teams, one each for us: entry, ascent, and orbit so that we could start working on products. Flight rules, for example, would be one product. There are malfunction procedures that need to be done, some of which might have already been done. Those are really done by the systems people. Product development could start, and you would have the person that was going to be responsible to you later when we flew

the flight. I mentioned cohesion. That was important.

In addition to that we had some new things to cope with that we'd not had in other programs. My selection was probably the highlight of my NASA career, because it was a new program, a new spacecraft, or space plane in this case. We had a new dynamic phase for the mission. We had an entry and a controlled landing that flight control would need to support. We got a head start on that with the ALT [Approach and Landing Test] Program, for example. Don [Donald R.] Puddy and his team got a chance to work with the crew doing ALT. [Richard H.] Truly and [Joe H.] Engle and some of those guys flew *Enterprise*.

It was a new phase for us that required some additional products. Other things you might not think about, weather. You got an airplane now. You got to think about the weather. It's more critical at this point because you're going to try to land on a runway. You don't want a crosswind that's going to blow you off the runway, or you don't want a heavy tailwind. If you needed to abort you don't want to try to land in an area that's going to have bad weather so weather became more important. An example of that would be TAL [Transatlantic Landing], which we'll get into a little bit later, having to abort and make a landing in Africa. That factored into flight rules. How much wind could you have in different places to commit to launch?

Other programs, our entries were ballistic entries. It was pretty straightforward. Do a retrofire. You could do a little bit of cross-ranging by moving the c.g. [center of gravity]. But you had a big ocean. You had a big target. Whereas now you're going to land on a runway and put the wheels down on it. So that was new.

The program was different with respect to like I said a new spacecraft, new dynamic phase, those things. But we had a good blueprint. Yes, we had the new phase—entry—for

example, but we had a blueprint of our past experiences. There was a platform. We knew how to do things. We had done them.

Some things would be new, but we knew how to approach those things. For example, we did what we called flight techniques meetings, where we decided on the options available to us for ascent abort modes. We had to add some stuff for the entry phase, so we had a proven blueprint to start with. We didn't have any surprises except just learning new things, new systems.

STS-1 itself, I had personal worries. I showed you a photograph of a Shuttle at launch and all the elements involved. It shows the solid rockets and main engines burning. It's just off the top of the pad. That lift off worried me from the beginning. First off, this is the first time we ever flew a manned vehicle without flying an unmanned spacecraft to demonstrate it was going to work and it was going to be safe, so that was a new thing. I wasn't involved in that decision. That was done at a much higher grade level than mine. That was already decided. We're going to launch the first Space Shuttle manned.

If you look at the Shuttle it's what I call an asymmetrical shape. Anything else you've seen launched is a cylindrical shape, round, one stage stacked up on the top of another, very streamlined. Made to go fast. This thing is sort of a big tank with a couple of big cigars on either side and then somebody thought well, let's put a vehicle on the stack kind of like an afterthought. It's very asymmetrical. Meaning you've got to model all the pressures associated with that launch when those engines start. You need them for design, obviously. You got to make assumptions to model those kinds of things. It worried me how well we could model all that power on the pad when we launched and not have an accident, have something blow up.

As I mentioned earlier, we did have some damage—we'll talk about that a little later—that we found after the STS-1 came back, and we could examine the vehicle. So that was a worry to me, just the complexity of all that power. Like I said, don't forget the back pressure coming off the pad. The pad is an element, the Orbiter is an element. Each of the SRBs [solid rocket boosters] is an element, and the ET [external tank] is an element. All of that had to work together correctly, or we were going to have a problem. That was one of my worries. Now I couldn't do anything about it except just worry about it.

Along with that is the crew had no way to abort in the first two minutes. Those SRBs are burning, and you cannot get off. That's a little over two minutes. Later we lost a crew when the *Challenger* [STS-51L] exploded during the SRB burn. That's another thing, there was no abort capability early on. The next abort possibility would have been the Return to Landing Site, RTLS. That was not much better than not having anything. However, it was a possible way to get the crew back to the landing site.

Then we had the other abort possibilities we'll talk about a little bit later. Let me see if there's anything else here I wanted to mention worry wise. Everybody worried about the tile. I mean everybody. I think the media worried about it. We worried about it because it was unproven, and there was no test flight of it either. Thinking about gluing 24,000 pieces of tile onto an airplane and flying it—it was almost beyond comprehension that we could glue tile on the Orbiter and protect it during entry, but that was the design. As a matter of fact, at that point you're just trusting the design to be right because if the design you had didn't work you were going to lose the vehicle and maybe the program.

Let me talk about the day we launched. I got most of the beginning started. I think it was a Saturday, but I don't remember for sure. I got up, got dressed, ready to go to work. My

daughter was a tour guide at the time, and she got up. We were going to watch the launch from home. I remember sitting on the edge of my chair and adrenaline running a little, a little bit of anxiety. About the time they got to switching from external power to internal power on the Orbiter, about three minutes before launch, my adrenaline and the anxiety just maxed out. Watched on the edge of my seat, knowing that we had to get past SRB separation. That's the first critical step. I don't think I need to go into all of them. Getting up high enough if we had a problem then we had a good chance the crew would survive; we could land. Probably after RTLS, that was not, we didn't think, a real viable option.

The next abort phase was transatlantic landing, TAL they called it. That's where you could reach the Africa coast and land. We had sites over there, runways over there. Morón [Air Base], Spain, that was up on a high inclination flight. One on the African coast, I don't remember the name but that was an optional abort. Then the next one I think was abort once around, AOA. Enough to get you into orbit but just once, you were going to have to come right back down. Then the ATO, abort to orbit, you were up. Then you get to MECO [main engine cutoff].

I went through every one of those, like I said with high anxiety. As it got higher and higher, my anxiety level, I'm sure started decreasing, so did my adrenaline. I got up after the MECO to go to work. I had my badge on, my MOCR [Mission Operations Control Room] badge, and I stood up. My daughter said, "You got tears rolling down your cheeks." I think I probably said, "People just don't realize how complex this is." Then I drove out to the site. I went to the console and took a handover from Neil [B.] Hutchinson. Matter of fact we were both still in the MOCR. He hadn't gone over to do his media debrief when we saw the missing tile. Those are my feelings the day of launch. Finally, relief, but that didn't last long.

We weren't expecting to see a tile problem immediately. We had just launched. That was a shock. We weren't expecting it to begin with, but there it was. The rest of the flight was all tile—trying to figure out the damage and how severe it might be. The fact of the matter is there's nothing we could do about it. No matter what the situation was. We were going to come back with whatever we had, good or bad. The critical thing we needed to know, if we possibly could, was what the extent of the damage was on the bottom of the vehicle. But there's no way we could do that without some kind of assistance. That got Gene [Eugene F. Kranz] coming in and working with our national resources to try to find a way, because it was critical. If we'd come in and lost the vehicle coming back, we wouldn't have known if it was tile. It was really a critical piece of information. I went over for my post-shift debriefings with the media, but Kranz was doing all the talking. They were after him, pumping him for any information they could get about what we were going to do and how we were going to do it.

When I came in for my last shift, I could tell there was some lightness in the air. I knew that we'd gotten something. I knew whatever it was was good because it wasn't so gloomy in the room. I asked Puddy—he was the flight director—he was on console. I just handed it over to him, "I'd like to sit and wait and see how it goes." He said, "Yes, plug in." The thing I remember about entry, of course, was first coming out of blackout; we made contact. That was a big plus. We'd gotten through the worst of it. Then watching the landing. But I guess the thing that topped it off for me was after the landing John [W.] Young couldn't wait to get out of the Orbiter. Left Crip [Robert L. Crippen] up there by himself. He raced down the stairs as soon as they opened the door, ran right past Abbey with his big G suit on to go examine the bottom of the Orbiter. A big grin and one of those victory punches. I

thought, we got it made. That's what I remember about the entry, him.

ROSS-NAZZAL: You must have been so relieved. It sounds like for those days leading up were very tense.

LEWIS: I tear up now even talking about it. But in the Control Center, I couldn't hold it back. A lot of other guys couldn't either. It was so much relief I guess that we got them back. Always teared up, always.

ROSS-NAZZAL: That's interesting that you say that because Mission Control, you're associated with the concept, "tough and competent." To hear that there were a lot of people working in the MOCR who teared up at this first successful conclusion.

LEWIS: Yes. I saw White Flight [Kranz] tear up a few times too.

ROSS-NAZZAL: Especially Gene.

LEWIS: That was STS-1. Let me look quickly to see if I had anything in particular.

ROSS-NAZZAL: Did you feel reassured after STS-1? You said, "Boy this was such a complicated machine." You had flown once.

LEWIS: After watching Young it wasn't clear to me. We were safely down, which meant we

probably had the program. How bad were things? It didn't look bad to us at that time. But it turns out there were APUs [auxiliary power units] on fire in the Orbiter, a couple of them, two out of three. Later they found damage to the body flap that was severe. Up in the front, one of the RCS [reaction control system] tanks was damaged. That was probably from "oil canning" of the Orbiter that caused that to happen, probably when the SRBs were lit from the pressure waves and bending of the vehicle. We had some heat leakage during entry. One of the wheel wells got hot, took in some heat, and was damaged. Didn't damage the wheel, but the wheel well—we had some spots like that where heat had gotten through. The worst of it was probably the body flap. We could have lost the program. We didn't know about that till they got it back to the Cape [Canaveral, Florida] and started examining things.

When I saw Young go down and inspect it with a big grin on his face, I knew we were going to have a program. Let's see. The tile, I just wrote, "Whoops, damage! Missing tile on the pod." That was one of my notes.

ROSS-NAZZAL: Kind of a big whoops.

LEWIS: My first thought, I didn't say it out loud, was, "Oh shit, what's the bottom look like?" Neil admitted thinking the same thing; he was sitting right next to me. "Oh no!"

The E&D [Engineering and Development Directorate] did a quick analysis of the OMS [orbital maneuvering system] pods when they could see the damage. They figured that it wouldn't be an issue. The only issue was the integrity of the tile on the bottom. We needed data. We needed data desperately. It turns out we got lucky. We got some. That's STS-1 unless you had something else.

ROSS-NAZZAL: Did you agree when Chris [Christopher C.] Kraft said that you were infinitely smarter? Or did you feel like there was still so many unknowns?

LEWIS: I thought about that. I don't know just what he meant, in the sense becoming infinitely smarter. I knew we were obviously smarter, and we were successful, because we had got them back. That was it. I guess my thought was—to me it was like sharing a joy. I have thought about it as perhaps his way of expressing the shared joy with everybody, that we had solved a very complex problem with an outside the box design. Who would have ever thought about using ceramic tiles? I kind of thought about it in that sense.

The other thing, after you think about it, we had just transitioned from a spacecraft flying at 17,000 miles an hour through every sonic flight phase you could. We had hypersonic, supersonic, transonic, subsonic, all the way down to a little over 200 miles per hour and a wheel stop on the runway. We'd gone through every flight regime you can name and successfully landed the airplane. Yes, at that time you can call it an airplane. Amazing, if you think about what we'd just done. I don't really know what he meant by that, what was in his mind. It was just overwhelming and fantastic. We got it done. We learned that we were going to have a lot of fun with a lot of capability and versatility. The Orbiter could do a lot of things. We had an arm we were getting ready to fly on the next flight. We were going to have a lot of flights to look at. I call it fun because the twelve years I was a flight director was the funnest part of my career. I think probably everybody said, "Okay, we're ready to go." Then you talk about STS-2.

STS-2, one of the things to mention is we had already—prior to STS—as part of our

products and our efforts to understand what we were up against and the "what-if" game, if you will. My orbit team had already gone through a case. What would happen if we lost one fuel cell, what would happen if we lost two fuel cells' of course a third loss is unheard of. We didn't want to think about that one. We'd already gone through that exercise.

One of the differences I should have mentioned earlier is we didn't have batteries like we had in other spacecraft. We only had the fuel cells. They were our only power source, so they had to work. But we had gone through that case and knew that it was no-go, that we needed to get down, because if the vehicle lost a third fuel cell you're in trouble. With two down and only one left, if I remember right, because the detail escapes me now, we could just barely get up one string of avionics. We'd have hardly any redundancy. In that case too I think we were doing some power up and power down as we were coming in. Powered down something we didn't need. Powering up what we might need ahead of us. We knew we were going to have to come back. The rule is: lose two fuel cells and you're coming home and that's exactly what we did. We delayed a little bit, but part of that is getting set up for your primary landing site, getting back into Edwards [Air Force Base, California].

Only four hours into STS-2, we lose a fuel cell. No-go. Primary objective on 2 was the RMS, remote manipulator system, and to get another flight up under our belt. Maybe a little bit more testing on the stability and control of the Orbiter during entry. I think we did some. That was an objective, not pushing the envelope too far but a little bit wider on the entry. Truly decided he would stay up through his sleep period and run as much of the RMS testing as we could. Bill [William D.] Reeves and his guys were the systems guys on the RMS and they had already identified the contingency DTOs, contingency detailed flight objectives. Meaning if we had to cut it short, what were the highest priority tests to get done.

Matter of fact, one of the managers renamed it, said, "Be positive, don't be negative. Call it your priority detailed test objectives." Truly started on those early on, probably even before their sleep period, and went all night pretty much. Engle claims we didn't know they were doing that. We did. We were watching telemetry. You think I could have told Truly to go get some sleep? Not hardly.

We did a lot of testing, got some good data. Engle managed to do some of the maneuvering that they had planned to expand the look at our Orbiter stability and control system during entry. All in all a five-day planned flight turned into two, but we probably accomplished eighty percent of the objectives we set out to get. Good flight.

ROSS-NAZZAL: When you made that call to bring the crew down did you have to go brief Chris Kraft of anyone else in the Agency about your decision?

LEWIS: No. I didn't make the call. It happened so fast that Neil Hutchinson—we hadn't even changed shifts. So Neil made the call to shut it down. The rule was clearly written. I don't know that Neil had any issues. I'm sure there were some questions asked because Chris and those guys wouldn't have read every rule. They were probably told one down, and we have to come home. I don't remember any negative feedback or questioning in a negative sense.

ROSS-NAZZAL: I wondered about that. It was so early on in the program.

LEWIS: Yes. We haven't got quite there yet, but early in the program STS-1, 2, 3, and 4 was the OFT, the operational flight test phase. We did the first flight, STS-1. We did 2 and lost

the RMS. We did 3 had to land it in [White Sands, Northrup Strip] New Mexico because the Edwards runway was flooded.

Then we did 4. We had a hail and rainstorm before launch, and it damaged some of the tile. We carried a classified payload. So it was a quick OFT phase with some unique things happening like having to fly into White Sands. That flooded runway, that was unreal. Then we did 4 and it was a DoD [Department of Defense] classified payload. I'm trying to remember.

ROSS-NAZZAL: How much did it complicate things for you having a DoD payload?

LEWIS: I didn't even know what the payload was, and I was the lead flight director. I did not have a need to know. The thing I was worried about was we'd soaked up some water into the tile during that rainstorm. We were worried about that. STS-4, I remember the complications we got because of the hail. We lost an MDM, another acronym, multiplexer/demultiplexer I think is what it was. It's a way to get data from your sensors to the crew's displays or telemetry. We lost one of those, and it was a hard push to launch on time, probably because of the DoD payload.

We had to fly an MDM out from California. Probably one of the crew took a T-38 out, flew it back, and they got it on and in. We did launch on time. I think when we had the hailstorm we got some damage, and they did some repair on the pad, as much as they could reach. But then when you push back the gantry around the Orbiter you don't go all the way around it. You got some exposed part of the Orbiter.

I was worried about that primarily as the flight director. The DoD thing I didn't have

that much to do with. As I remember it, the way they worked that is we had a couple of DoD guys, probably first lieutenants or captain level guys, that we worked with on the simulations. The crew had a set of procedures on board. All they had to do was tell them, "Look at procedure number X and do it." I don't really know how much involvement there was except we did have some classified books on the console.

I do have a little story about that. Classified books are normally marked. You can see it's classified. It's done on purpose. You want it to stand out so you don't leave that one lying around. You want to take it back to the safe with you.

I told one of the DoD guys. I said, "Those classified handbooks stand out because of the classification that's written on them. You can see them all the way out in the VIP [very important person] room, certainly off the last row of the consoles. It draws attention to what you're doing." "Well, we can't do anything about that. That's military security regulation."

One day later first time I had met, and I was briefing—I guess it was the commanding general of that particular entity. I was briefing him, and we were standing up in the VIP room looking down.

I said, "General so-and-so, I made a comment to your guys that having those books out with the classification showing only draws attention to them. I'd suggest that we take those off." He said, "I agree with you." So they took them off. But the lieutenants and the captains just didn't have enough swing, if you want to call it that, to get it done. I can understand that. He had a high enough rank that he could probably do it and not get anybody in trouble. That would be the story I'd remember out of STS-4.

The other thing is because water had been absorbed, we did some maneuvering to expose the areas that we were concerned about to the sun, to vaporize the water. Our concern

was if we had water in the tile and it got cold—and it would in orbit—it could crack. They're brittle. Then you could lose a tile. We did a test to see if we could close the payload bay doors. It wouldn't latch.

I found out later. It really spooked [Thomas K. "T.K."] Mattingly and Hank [Henry W. Hartsfield] because they thought, "Oh, God, you got to get the doors closed to come home." We went into what we used to refer to as passive thermal control, PTC, where you're slowly rotating the vehicle. We had banana-shaped the Orbiter because the temperature gradients on the Orbiter—heat expands, cold contracts. We'd done enough of that. We had the doors bent a little bit, and they wouldn't latch. So we did some maneuvers like that, but nothing happened.

But they forgot to do a test that we had set for them to do just in case it happened. We put a target on the aft end of the payload bay and a sight at the front, so if we did get into a situation, they could measure how much deflection we had between the forward bulkhead and the aft. We'd get an idea of how far off we were to getting it launched, how severe the bending was. They didn't do that test. They forgot all about it. I don't remember much more about 4. Those seem to be the highlights in my mind.

ROSS-NAZZAL: You did share a story with me about a simulation where one of your controllers had mentioned, "Oh, this is good enough for government work." You said that you were upset about that, that you wanted the best, not just close enough.

LEWIS: How can you tolerate something like that? Good enough? I think it really goes way back when I was growing up. We didn't have a whole lot. We had very little as a matter of fact.

I was born in 1937 so I was old enough to remember a little bit after the war. We were having some hard times. Daddy couldn't find work, that kind of thing.

The people that did have work were people that worked for the government. They always seemed to have a job. When the guy said that maybe I reached way back and thought, "Damn government worker." We were struggling to eat. That might have been it. But the fact of the matter is you can't accept an attitude like that. That's not an attitude you want to dwell with your team or stick with your team. It's not good enough. You got to be the best. We have to be the best. We were government workers, but I figured we were a different class.

ROSS-NAZZAL: Is it because you were worried about human life? Is that what was driving your thought process?

LEWIS: Sure. You just don't want to make a mistake and you lose somebody or not even that, you just don't accomplish the objectives you're after. Your primary objective is crew safety and getting them home. That's flight control. You got to protect that capability. That's what we do. But there's a lot of other things you want to do. You want to accomplish mission objectives, like you want to accomplish an RMS test. There's going to be things to do with it on later flights. You don't want to leave doubt where you don't have to leave doubt. It's a combination of things. Just a commitment you take on that you accept, and you want to do your very best. It's like I mentioned earlier, you want a team of guys that you've worked with and got cohesion with; they're all there to do the same thing, their very best. Why would some guy make a comment like that? I don't remember who it was but it sort of pissed me off. Mike [Michael L.] Coats remembers that.

ROSS-NAZZAL: Oh, he does?

LEWIS: Yes, he remembered me getting upset. He mentioned that to me one time. I don't remember when it was. It was after he was center director. He said, "I remember that chat."

ROSS-NAZZAL: He's a good guy.

LEWIS: He is.

ROSS-NAZZAL: Your next flight was STS-9. That was a very different flight from your other missions.

LEWIS: That was really different. It was primarily, in my mind, and for me, a management job. It was trying to manage multiple elements of the program to accomplish the first Spacelab flight.

Back in STS-1 or 2 we had the Control Center and pretty much that was it and the vehicle. That was the activity. STS-2 the same thing. Throwing the Spacelab in brought in Payload Ops Control Center at Marshall [Space Flight Center, Huntsville, Alabama], a European Space Agency [ESA] interface. They interfaced through Marshall but at the same time they wanted part of the action in the Control Center. There were a couple of guys that I remember from ESA that were good troops. We had the first TDRS [Tracking and Data Relay Satellite] to provide communication and tracking support for the very first time. With that

they were going to have half an orbit of coverage every orbit compared to scattered remote sites, so that was another factor. We had one TDRS up and operating. I think with two of them operating we got about eighty-five percent coverage on an orbit, which was phenomenal compared to what we had in the past. The second one wasn't ready, but they were moving it to position it where they wanted it.

As an example, trying to work all the pieces, I talked to the manager at Goddard [Space Flight Center, Greenbelt, Maryland] about the TDRS. If we really needed it, if something happened, couldn't we get access to it? He said, "Well, if you really need it and something comes up yes, you can get it, but it'll mess up what our efforts have been so far trying to get it moved." That was just an example. You're trying to work many pieces, and you're interfacing with the lead ops guys from Marshall and ESA. For me it was primarily a flight trying to get all the pieces working together to accomplish the objectives.

As a matter of fact, I planned two long duration integrated simulations. Those were to simulate with all the elements that have to interface with each other on a shift-by-shift with their handovers over two days. Let me back up a little bit. In the MCC, the MOCR had their staff support. Behind them is the MER [Mission Evaluation Room]. That's the E&D support. You got a lot of levels of support. I wanted to get them all up together so that if we couldn't talk to one another we'd know it. Who was going to talk? Who were they going to talk to? What was their authority? We were going to practice it. We did that.

We had all those characters. That's what I wrote down: identify all the interfaces, whatever the authorities were. Communications, make sure all the coms were working. There was always trouble with Marshall with their communication systems on simulations. We did it, and I was asked by I think it was [Glynn S.] Lunney. He might have been program manager.

I asked, "Do we need the other one?" It was expensive to get everybody where they're supposed to be and do a long duration sim. The crew, they had to fake a lot of it, because they participated.

I went back and talked to some of the guys, and I thought we don't need to get another one. I told them, "We're going to be okay." Another one, we might get another ten or fifteen percent out of it. We got eighty percent out of it probably. We could interface. We could talk. We knew who to talk to.

One of the pressures I had, it was probably ESA and then Marshall as well. It was planned for a nine-day flight, and they wanted a tenth day and pushed hard for a tenth day. My people are here at JSC. They weren't flight controllers. Over in MPAD [Mission Planning and Analysis Division], they did our power consumption analysis. They had a way to do what equipment was operating, how much power it took. They could put all that together, so you have a model of your power consumption. They did that, and they could do the Marshall Spacelab too. But we never could get Marshall to give us anything but spec data. We didn't get real data, which they had. Kind of defeated our purpose for the Marshall payload side of the house.

I told the ESA guy and Harry [G.] Craft, or one of the Marshall guys. I said, "I can't do it preflight. But as soon as I can get a handle on the power consumption, then we can make a judgement. If we've got enough to do ten days, I'll recommend it." We did. I don't know how far we were into the flight, probably four or five days. I told ESA and Marshall they could plan on another day. At that time ten days was the longest flight we'd flown. It was the first Spacelab flight.

I'm trying to remember Spacelab-wise. Because of the TDRS coverage and the way

the Spacelab was configured as far as data was concerned, we got all kinds of data. We were even telling the media, "We got enough data in the last eight hours to print two encyclopedias." That kind of stuff. We were using that as a media advertisement. We did do a lot. I think as far as the science community was concerned, we met all expectations and probably exceeded that. I'm not the guy that should judge that. Bob [Robert A.R.] Parker and Owen [K.] Garriott were part of the crew. I knew Bob Parker from Skylab. He and Bill [William B.] Lenoir were the science guys for Puddy and Neil and Milt [Milton Windler] and me. They handled the science for us. They would work with the scientists, the principle investigators, and set up a day's work for us.

I knew them. Young, I was professionally, not socially, acquainted with him. I remember seeing Young on STS-9. You never heard from him. He had to do a lot of maneuvers. I don't remember why, but he was doing a lot of maneuvers. He was never on the TV. Finally I asked, "We need a TV shot of John and what he's up to." He was up in the forward deck just listening. Got a headshot. Somebody stuck a camera up there.

Everything worked great until the very end. We got everything tucked away and were getting ready for entry. I had just handed my shift over to Gary [E.] Coen. He was the entry guy. They were powering up the computers, getting ready to power everything up. I don't remember exactly how far we were from actual entry. We were getting ready for it and going into Edwards. One of the computers crashed, and Young had commented before that when you fire the jets up front in the nose, and that's where the computers were, it really made a bang. You could feel it when you'd fire one of those things. It wasn't long, and another one failed, crashed. We were down, two out of four. We had one stored, I think, on board. But here we are, we're more than probably a rev or two away from entry. I'm guessing a little bit

here.

The second one crashed, and what was happening, we found out later, is firing those RCS jets up there was banging the vehicle and breaking off pieces of solder inside the computers. I called them solder balls. They're in zero G, and they float around. If you break something off, they're going to float around until they get on something or land. I guess you'd call it landing. It was caused by solder breaking away and then getting on the circuit boards. I remember one of the two that crashed, because we managed to get it back online. Gary needed to restring stuff because of the priority of the equipment. We wanted to get the best on the string one, so he started restringing. I was sitting there watching him wishing I could get involved. But he was the one to do it. He was the expert on doing that kind of stuff.

If I remember right, we got everything set up. Computers all where we wanted them. I'm guessing we didn't get one of them up but we got all we could. We were about ready to give a go for entry. I don't know how many revs later. I should have researched this a little more. We were going to enter on a descending portion of the orbit ground track as opposed to an ascending portion of the orbit track. Original plan, we'd come across the Pacific and come up from the southwest over LA [Los Angles] into Edwards. The orbit had moved back a couple of revs at least, I'm guessing again. Now we were entering off the Pacific over a descending portion of the orbit ground track from the northwest, over the San Francisco area into Edwards.

That's what we did. Just before we got ready for that, one of the three IMUs, inertial measurements units, failed. That's a prime piece of equipment. Can't give you the exact timeline but Gary then had to cope with that. I don't remember how he arranged the other two with regard to the strings he had set up. That was hairy. It got really hairy right at the end.

Everything worked out as I remember as far as the landing was concerned but got a little crazy. Brewster [H.] Shaw had his hands full there at the end getting ready, set up for the entry. That was my last flight. I'm trying to look here, nine days went ten. Talked about the elements.

That all worked out well, everybody was pleased. I guess later on one of your questions was about expectations. I thought Spacelab exceeded expectations as far as thinking back about flights and other activities. But that one was really a neat one. It was going to be my last one too. That's probably a factor.

ROSS-NAZZAL: Did you know that at the time, that that would be your final mission?

LEWIS: No, I don't think so. I don't think so because that was in November of 1983. In the summer of '84 I had two series of headaches through the summer back-to-back, meaning about eight weeks for each one. One ended, and another one started immediately. It was a summer I don't remember. I showed you that picture at the table with the other guys when I was in the Operations Integrations Office. That's when I was there. I was still doing that up through I don't when in '84.

Sometime in '84 Gene moved me over to become assistant for Space Station out of the Directorate Office. That's when I left and went over. I don't remember discussions between Gene and me. Although we were coming up on a period of time when whoever was going to head up the Flight Director Office was going to have his hands full. We were bringing on a cadre of flight directors. That photograph, I named a lot of them. Harold [M. Draughon] had flown entry. [T.] Cleon [Lacefield] and some of the other guys, [A.] Lee Briscoe, some of

those guys were flight controllers but not all of them were. They were bringing them into the flight director corps. Whoever was going to lead that office was going to have his hands full. The other thing is Space Station stuff was just beginning. It really wasn't well defined yet. Gene pulled me over; I think I stayed in the same building but put me in another office.

Space Station support. I think one of the first things I did, I was the operations lead when we did the Phase B proposals for Space Station. I think Neil headed that up. It must have been about that time. I led that effort. You asked what were some of the tasks I did. That was one of the first ones, which meant pulling together a team of operations people, not just in flight control, but MPAD and others to represent operations and evaluate all the proposals from our point of view and what we found good about them and bad about them. That was one of the early assignments. I think for whatever reason it was the right thing to do. Gene did the right thing.

I brought a pamphlet that describes cluster headaches. Rather than try to explain it, I just went through one of these. You can just glance at it. I marked what a cluster headache was to me. If you're not familiar with them.

ROSS-NAZZAL: No, I've never heard of cluster headaches before.

LEWIS: I know. Most people haven't. It'll tell you about them in two pages. I put yes by the symptoms I had and some I wasn't sure about and then how often I had them, at what frequency. They continued throughout my time in the Space Station Office until I retired. They weren't as bad as they could have been, because that summer I mentioned that was bad. Very unpredictable, excruciating pain.

ROSS-NAZZAL: It says it can wake you up in the middle of the night.

LEWIS: I didn't even sleep at night. I slept in a chair. Lying down would bring on a headache, may have anyway. About every two hours you'd wake up. I don't know whether that's from sleeping in a chair and just wasn't comfortable or if it was the headache. You never knew how long they were going to last, fifteen minutes, couple of hours. There was no medication for them, no preventative medication. They still don't have any. They got some other suggestions. They finally came out with a pain medication. I could kill the pain, I could get rid of the pain from a cluster headache early on, but it took Tylenol# 3, codeine and acetaminophen. By the time it was effective—it might take fifteen or twenty minutes—the headache may have been over. Sometimes they go fifteen minutes, sometimes they go an hour. You never could tell. If one got going really bad, they came up with a medication I could self-inject. Within five minutes it'd kill the pain. That progressed better as time went on and I had less headaches.

When I left, I was still having them. I remember a series in 1994 and another in 1999. I went several years and had a series about the time an uncle of mine was dying, and I went up and stayed with him in the '98-'99 timeframe. I think that was the last series. Carolyn says I had my last series in the fall of 2007-2008. She drove us on our trip to California because I was having headaches. Then they went away. They don't know what causes them. They still don't.

ROSS-NAZZAL: You don't suffer from them today?

LEWIS: No.

ROSS-NAZZAL: That interesting that they just went away.

LEWIS: It was a smart move. I managed to stay on, and I could still do some good work with the experience I had. We were trying to build up a team of people that worked Station. That was one of the tasks. Gene asked me to come up with what we called a construction of facility, CoF, for augmenting the Control Center to be able to do Shuttle and Space Station, because as the time we weren't going to be able to do everything in the old Control Center as it was with just two MOCRs. Another thing I did early on, probably about 1990, maybe 1989. He asked me to draw out a plan to continue to support Shuttle. Flight rate was going up. We were going to do DoD flights at that point in time. The workload was going to get worse.

Then eventually we'd have to have someplace, once we manned the Space Station, to have the Space Station flight control. I did that. The plan is as it is today except for one thing. I wanted a tiered floor in the main control room, and he wouldn't do it. He wanted to go flat. I lost that battle with him. I came up with the idea of a smaller control room, the white and the blue, because once we're on Station, you're just doing Station. You're not doing ascents and entries. You could do with a smaller team. You could also have the main team if you wanted to simulate, so you could swap them off for a short period of time.

I went up to do that. I went up to NASA Headquarters [Washington, DC] several times, I don't remember the time frame, I think '89, '90, to make a pitch to get it built. That wasn't easy. Construction of facility in the government is not easy to do. This was all NASA

needing to get CoFs up. Finally got it. Had to do battle with John [D.] Hodge, my old, old boss. He opposed it most of the time. Finally got it approved. They started construction in '92, it went operational in '98. I remember briefing some congressional people during the construction period in '92 because I went over and stood up with a bunch of sheetrock in the building so I could brief them on the building, what it was. That was another side task. It took some effort, some time. Then a lot of it faded away because I wasn't having fun.

ROSS-NAZZAL: It seems that way when we talk with people.

LEWIS: I wasn't having fun. Management, budgets, budgets. I got so damn tired of traveling to Reston, Virginia. Bob [Robert W.] Moorehead was the Space Station manager. I didn't want to travel to contractors on Saturdays just to have a goddamn meeting. Part of it got tiring, the budget stuff, just over and over and over. How about this? Try this, try that. Everybody was cheating on the budget. Typical, trying to get more than they really needed just to cover their butts in my view. Of course, behind that is the contractors. They're pushing to get as much work as they can.

ROSS-NAZZAL: What about *Challenger*? You were still here for *Challenger*.

LEWIS: I remember *Challenger*. Let me see, where am I ? We're at cluster headaches.

ROSS-NAZZAL: That's okay, you can stick with your notes.

LEWIS: I just had them numbered based on your number.

ROSS-NAZZAL: We're pretty close to wrapping up.

LEWIS: *Challenger*, I was in my office. There was a TV. At that time the managers had TVs in their office. A secretary or somebody else probably was in there too. I don't remember who all was in there. I remember seeing the explosion, and my immediate response as I remember it was, "Oh, no. How can this happen?" or something like that. You know what's happening but I wasn't quite ready to receive it or acknowledge it. Then I remember looking for the crew module as the SRBs spun off. I kept looking, realizing that there's no way they're going to survive it. But that was just my spontaneous, "No, it's not happening." Then maybe they'll survive. You're hoping there's hope, but there's not even any.

I was in Station then. It didn't affect me other than the loss of friends, because I knew a lot of the class of '78. I knew some of those guys. It hurt me a lot that way, losing the friends. Then the other thing I thought about, not that day, but I thought about it a little later, was the flight controllers that were on console. It happened, and they were just completely helpless. That's got to be hard to take. You're working with guys like that; you're doing everything you can do. There's nothing you can do, absolutely nothing, you're helpless. I thought about that. It had to stick with them for a period of time.

But it didn't affect my work or MOD [Mission Operations Directorate] work on the Station, because we weren't that far along. Just a reminder that space work is a risk. The riskiest part is that launch, that why it bothered me even more so thinking back. Both of the Shuttles we lost were lost on the launch phase; the failure was on launch. *Challenger*, the

SRBs blew up. On *Columbia* a chunk of insulation came down off the ET and hit the leading edge of the wing, knocked a hole in it. We didn't know it until we started across Texas. So launch got us both times. If we'd lost STS-1, it would have been body flap, hydraulics got torn off. Spaceflight is risky business, and that doesn't change.

On the Station, what changes, you go up, you have to go through a launch phase to get up there, which is always a risk, but you're not in any dynamic—well, I guess you got the entry to think about. You still are faced with going up and coming back no matter what. The activity on orbit is maybe not as risky because it's not that dynamic. I would say that it's always risky. If you get hit by a meteorite, for example.

Launches are the bad time. Mostly entry, only issues really came to be primarily because of the plane. We had to come in and fly an airplane through what I talked about earlier. The *Challenger* was a loss of friends and recognizing it's not something you take lightly. You asked about what I thought was the most successful.

ROSS-NAZZAL: Your greatest accomplishment. If you had to look back and point to something.

LEWIS: I thought about that. I thought what would it be. I thought about Apollo 11 obviously, the landing. Even though I was not as active, I was there, I helped get there. So 11, that's probably number one. Number two I'd say Skylab. We recovered from a catastrophic launch failure on the workshop and managed to complete and probably exceed program objectives. Brought that back to life through the work of primarily astronauts [Joseph P.] Kerwin and Pete [Charles Conrad]. When I say us, I'm always talking crew and us too. It isn't done unless

they do it, pretty much. At their risk, getting the other solar panel out and getting the shade up. Then the other one would be STS-1. Here's where I put my note. My best twelve years, flight director. That was the fun time.

ROSS-NAZZAL: How about challenging times? Was there a point where you would say, "This is my biggest challenge?" Something that you had to overcome?

LEWIS: Only in a general sense. To me, and maybe this is why I had the headaches, meeting or exceeding expectations for my flight control team, the flight crews I worked with, and NASA management. That's why I mentioned earlier the one that I remember I thought exceeded expectations was 9. Probably STS-9 and Apollo 9. I didn't put down Apollo 9, but I remember preparing for that one. I think I mentioned that one back when we talked Apollo. Briefing [Robert R.] Gilruth and the crew about the way we were going to do communications. That was 9.

The other, we managed to get the job done. I guess I could put STS-2 down as exceptions. Because we had already prepped ourselves and were ready for that one and we got in short order with the help of the crew, we managed to test the RMS and get it done after we had the fuel cell failure. Probably they met expectations. You're always hoping you get it done, and get it done completely, and get it done right. You don't end up screwing up something. You're always expecting your expectations have to exceed something bad, have to be good. But I forgot a lot during the last few years.

ROSS-NAZZAL: Like you said, it wasn't fun. When we talk about management positions—I

think we had a chance to talk with Chris Kraft, he told me that being center director was probably the worst years of his life. It was just such a tense time.

LEWIS: You know what he told me the best year of his life was? Mercury Control. I asked, "When did you have the most fun?" I don't remember when I asked him. It wasn't way back. I didn't know him that well. But later, he said Mercury Control. He said, "It was mine, all mine." Something to that effect.

ROSS-NAZZAL: Yes, that's funny.

LEWIS: "It was mine, all mine."

ROSS-NAZZAL: Did you decide to retire because of the cluster headaches, or were there reasons?

LEWIS: Primarily, that was a big driver. I was still having them. Maybe I wasn't having them as frequently as I had them getting out of the Flight Director Office. But I was still having them. I first thought about getting out, going to work for a contractor. I even interviewed with IBM [International Business Machines], and I was basically hired. But then I thought more and more about it. I thought I'm just turning around and getting right back into the same thing; it's not going to help me any.

I had I think thirty-five years counting Goddard and White Sands [Missile Range, New Mexico], thirty-five years in. That was 1994. Yes, I was young to be retiring, but I was ready.

I'd worked hard enough. Carolyn wondered why, and the kids wondered why is Daddy quitting. If you ever have a cluster headaches you'd know why. After I got out, like I said '94 I had a series and 1998 to 1999 I had one. I remembered my favorite uncle lived in Oklahoma, and I went up and stayed with him. He had myeloma. He was dying. A lot of the family lived there. I could do it. I could go up. I had a series when I was there.

As a matter-of-fact Carolyn said that the other day, "We often wondered why you quit." I said the headaches. The kids asked the same thing. I told them, "Well, Daddy has worked since he was in the fifth grade. He said he thought he'd worked long enough." Paper routes and grocery stores. Junior college. It was good. I stayed pretty busy. I guess another reason I liked Skylab is I like to fix stuff. I fix all my appliances that break. They're getting to me though. I can't do a circuit board, but I can replace relays and temperature sensors.

ROSS-NAZZAL: I should put you in my phone contacts. Is there anything else that you wanted to chat about that we hadn't talked about?

LEWIS: One of the things that I remember, and I think I remember telling other people at times. I said, "When I started, communications in the world were teletype, if you even had that." I remember going to Zanzibar and how bad the communications were. Then the last Shuttle flight I flew, we had one of the first TDRS satellites up, and we used it. We had more communications than we could stand. Over that span of time, we saw a lot of change. We saw a lot of change in flight control, thinking back. Kraft's concept and the principles that he used were everlasting. I told you the story. His management style was go through your boss and tell him to pass on that you did good or suggest options for doing better. I asked, "How

did you figure out how many remote sites to have?" He said, "Well, there's two reasons. Back then if you flew across the United States on a commercial flight every twenty minutes radar would pick you up and track you to find out where you were, your heading, etc. I used that as a guideline for contact frequency, twenty minutes."

He then had to look at the first three orbits. How could we get maximum coverage the first three revs [orbits]. You've seen the sinusoidal orbit tracks as they move around the Earth. You're moving across different countries and places. He said, "I wanted to get at least three orbits of good coverage. If we had a problem right off, we had a little bit of time to work on it." You were still capable of coming into a primary landing area. He had rationale that he leaned on for his decisions. I asked him one time if he had a photographic memory. "Do you have a photographic memory?" I think his answer was, "Not quite." But people would tell me years later, he'd be briefed on something, or they would bring something for him to read before he'd go do a press conference. He could brief the press at various levels of detail without referring to notes. If you asked him another question, he could make it a little more detailed. Close to a photographic memory? A smart man.

ROSS-NAZZAL: Yes, Good talent.

LEWIS: Yes, good boss. Couldn't have had one better.

ROSS-NAZZAL: Thank you for coming in, Chuck. Appreciate it.

[End of interview]