ORAL HISTORY 3 TRANSCRIPT

JOHN S. LLEWELLYN, JR.
INTERVIEWED BY KEVIN M. RUSNAK
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RUSNAK: Today is February 24, 2000. This interview with John Llewellyn is being conducted in the offices of the Signal Corporation in Houston, Texas, for the Johnson Space Center Oral History Project. The interviewer is Kevin Rusnak, assisted by Carol Butler and Sandra Harvey.

I'd like to thank you again for joining us today, and if we could, I wanted to go over just some general questions about your job, specifically in Mission Control. We talked about how you got into the Retro [Retrofire Officer] position, but I guess we didn't really talk about what the responsibilities of that particular position were and what types of activities you'd be doing while you were on the console, and in between the missions.

LLEWELLYN: Okay. Of course, I was basically the—my responsibilities, of course, with all of us, crew safety. Manned space flight—that was something that we really worked on and thought about all the time. Of course there was the mission success, too, to get things done.

My job was in three phases. Well, it was really four phases. It's the pre-launch phase, it's the launch phase, and then, let's see, orbit phase, and then reentry, de-orbit, and, of course, post mission. That essentially takes it out.

The pre-mission phase is what we did, knowing when we were going to launch, we backed off and had a certain period of preparation and making sure all the products and tools and equipment and things that we're going to use were correct. And we had the changes for

each mission and the new flight plan. By the time we'd gotten around to Mercury MA-6, we had pretty well determined we needed a real flight plan. And I'll go into that.

Then, of course, it's the training and all of the milestones that you had to make sure that your particular organization or your responsibilities had meetings and check numbers and that kind of thing. Then it was the simulations, and that was kind of—in those days we went and lived at the MCC [Mission Control Center] and were immersed in that. That kind of follows all the way through, even as far as going into Skylab. We kind of did that same kind of thing, even though we lived at home, but we actually did final preparation and simulations, that was always intense and pretty well absorbed all your time and thoughts.

So after that, then, of course, you had your pre-launch testing. That at first was fairly simple, running through the counts and knowing what you were doing. Then as the complexities got in it, of course, was more on-board complexity, things that, of course, the people had on the ground and check it out prior to going.

Then we had the getting inside into the fuel and the countdown and the command checks and all of that. Since FIDO [Flight Dynamics Officer] and the Retro had commands, FIDO had abort command. I guess you guys went over that with Jerry [C. Bostick] yesterday, didn't you? I imagine he talked about that. Of course, I had a retrofire—I could fire the retrorockets from my console, which put that a big responsibility, part of the checkout, the systems, the thing.

The other thing I did was responsible for the on-board timing, because the timing and synchronization of that whole system was important. Well, one second is four nautical miles, just plain—you know, just like the stuff the navigation guys know.

Then the responsibility of the launch phase was to be aware of the trajectory and had to know that and had to know the FIDO's job, but also so I could anticipate the things he said. And we trained that way, and we even switched positions.

My job was that once that we had abort and we didn't make—were not going to make orbit whatever happened, I had to turn around and in just a little—just seconds, and get the system, the reentry, get it separated and get in the attitude and then make sure that no matter what was happening, that he fired those retros, because we wanted to know exactly where he was.

In those days we did it strictly on time and we did a ballistic reentry, so if we knew the time and trajectory well enough, and he rolled the spacecraft, which gave you no lift, we knew exactly where to look for him. So that's what we had to do. So that was a really tough job for the Flight Dynamics Officer and what turned out to be the reentry also, retro, whatever you call it, abort officer, or whatever you call it. Of course, we picked up names like FIDO, Retro, so that's what we ended up with.

That was a really, really tough part of the training and a really tough part of the mission, that part of it, because you had everything. You had powered flight, and then you had to make sure he got in retro position, and he knew where he was, and you didn't hit land, and got all those kinds of things, winds and stuff like that, so we had to know a lot.

And we dealt with all of the organizations, too. That was the other thing. But I'll get back on that again.

Well, that got us through that, and then we had the orbit phase. That's kind of discontinuity, you know, in physics. It's not really, but you finally add an altitude, add a velocity, add a flight path that defined what that orbit was and that's what you targeted for. But

for the Atlas it was very marginal. In fact, the separation velocity between the spacecraft and the booster was enough to give you orbital velocity. If you didn't get it, you might not make it. So that was a tough one, and so you had that delta V [change in velocity] at twenty foot per second, which is about ten nautical miles in apogee on the other side. It's real simple stuff that you had to learn.

That was always a real time of anxiety, did we really make it, and if we didn't, we had that real problem of going into Africa. We just couldn't take a land landing with that spacecraft. We just didn't want to do it. So that was a real tough thing for the reentry people and the FIDO, especially for me because I had to get a vector and get a time and turn the thing around and fire retros and make sure it wouldn't hit Africa.

The bad thing about it in those days, remember we didn't have good communication between Bermuda and Canary Islands, because Canaries could see it, but since I was there a lot, I knew that situation, so I could almost—because I'd been there as a Capsule Communicator prior to being a retro, I had worked at part of it, so as far as the guys in the Control Center, I had already gotten that picture, you know. I knew the space and time problems and forth, so from that standpoint that was really tough.

Then once you got it, then there was so much stuff that you had to get ready for, because we wanted to make sure, if the crew had to come in, we wanted to make sure that he had a good retrofire time and then attitude and those kind of things, so we'd know where he was. And we came to what we called planned landing areas and contingency landing areas. The contingent landing areas were always supported by landing recovery. No matter what was there, we always had, for the planned landing areas, they had carriers and helicopters and all that.

For the contingency landing areas, sometimes there were just destroyers and perhaps some air support of some kind. But you could call in divers. We would call C-130s and drop people in, and they were the rescue people and the Navy SEALs [Sea, Air, and Land]. They weren't SEALs then, but they were just—so we had good support. We really did have this thing. I think that was characteristic of the Mercury program in starting off that way, and we continued it right on through.

Let me see. Then the orbit phase in the Mercury was always difficult, because we didn't have really good definition of the orbits. The tracking, the drag model we were using, almost—just the techniques we had for orbit determination hadn't been developed yet. Even though we'd flown a lot of spacecraft, unmanned stuff, we had not flown the kind of missions you needed, the type certainly that we needed for manned flight, so we developed a lot of that, integration techniques and understanding, and a whole lot of people helped us. Gosh, that's the main thing about Mercury is the industry and the academic and anybody would—if they saw something that they needed help on, they'd do it. They'd come to us and tell us. We had a real good—NASA at that time was extremely good technically. I mean, gosh, as far as those disciplines it took to do this, they had done a lot in aerodynamics and a highly evolved technical team.

So the next thing, in the orbit phase, it was listening to the systems and the resources and the flight directors and the landing and recovery people for the areas and what the weather was here, and then the Flight Dynamics Officer was continuing to determine the trajectory and what we thought we were going to look at for the end of it and what did the times looked like and all that. See, we all had three orbits. So anyway, that was hectic.

Plus we had, in those days, before we had all those displays, we were the only ones that had the real good updated acquisition and elevation and that kind of thing, the actual LOS [loss

of signal] times for the range for all of the remote sites and tracking and everything. That was my job to fill those things out as we saw them, because we didn't have any other way to do it and send them out by low-speed teletype. That's how it went out.

Goddard [Space Flight Center, Greenbelt, Maryland] had a way to start it, but I think sometimes Mercury—automating the Ac [Acquisition] and LOS to our sites, but the difficulty there was, since they might have sent based on the wrong vector, and in those days if we wasn't right in there, like in one, two seconds, that just disturbed everybody. So we got, because of those kind of things and we spent so much time on that, and it was so well determined, that we wanted to make sure that what we predicted was right on. Something's wrong, either the acquisition stuff was wrong or what we were doing was wrong. We checked ourselves all the time, and it was constant. Just between just that in itself, the trajectory and the orbit stuff and tracking and all that, that was a discipline that we developed all by itself. It was just a total thing that went on.

That kind of thing goes back to what we did when we wasn't on console, because it turned out that we, the guys who did it, were the ones that wrote the requirements for the system. So it was a real interesting thing that evolved. At first we thought that we'd just do the missions and have our own job, but we ended up kind of being in a project, a total management thing. We became all system engineers. I mean, we were constantly doing things to improve the total system, and that's what we evolved to.

I don't know if anybody's ever said that besides me, but it looked like that's what we ended up doing, and it was a full-time job. In fact, it didn't take us very long, and [Glynn S.] Lunney and I had to think about who we were going to start training and adding people to the thing, which was another responsibility that he and I put a lot of time in. In fact, Jerry—I

trained Jerry. Jerry was a Retro and then he went to FIDO, but I know him very well. There was another guy, named Tom [Thomas F.] Carter [Jr.]. At the same time those two guys come in. But that was constantly going on. So those kinds of things, and then, of course, the reentry part, the orbit, the deorbit, was a fixed time and we knew exactly when to start that.

I came up with what we called a retro work schedule, which turned out to be the flight plan. I will have to admit that. I was the one. Knowing where I was going to be at, I'd back off and start planning on my latest data what ship's eyes could see and when is the last site, and when is the last vector, and when the FIDO had to have a vector. Then when we ran the last time, and then when we passed it up, and then the whole thing. Then the on-board clock, of course, was our responsibility because it had lockouts. That's a little bit esoteric to get into. That's a talk all by itself, but that's what happened to [M.] Scott [Carpenter], his clock. Scott Carpenter, he was out of attitude, and because of that, the retros wouldn't fire, what we fired from the ground.

So all of that was what we did. Of course, we had the retrofire, and then the next thing is that whole reentry phase is doing the best we could do with all kinds of things like blackout times. If the blackout time was exactly what we expected and we didn't get into telemetry and we could get tracking, that really made us feel good if that thing was right on.

And we started computing those kinds of things, too. That's something that real time, as we went through this thing and realized those were really critical milestones, if you want to call them. "Events" really is a better word. We started, since we—Newton's equations actually determined that stuff, which is really incredible. We talked about it last time. That you actually computed and then you watched it. You had the equipment, and damn if it didn't happen. It was really just a great point for anybody to be in that position.

Then we had the chutes and that whole thing. In those days we could only imagine it, you know. It got so that we could start seeing it, which really was incredible. We had the ships there with TV and watching the thing come down. That's really a great look to see the main chutes open and no Mae West [life jacket] and no anything.

Then we had the post-flight stuff that we did. That lasted, depending on the complexity of the mission, it went on for a lot, because that's where we went back and kind of vetted ourselves and went through the whole thing and made sure we all knew what we had to do, so we could upgrade and do the next mission.

But the real thing that we had to do was, and it took a lot more time than I think anybody would have thought, was the going back, and it really, by the time we got to Gemini, it was really significant because we were flying them so close together, it was really a lot. Not only did we get ready for the missions, but trying to take the stuff we learned, and so we'd get into the next generation, the next thing. Plus the fact tweaking up systems that we had already available. It sounds like the same thing, but it's not, because what you do is, you see ways that you really got trouble with and you implement something new, but in order to implement that, you have to think it through and write your requirements and get the thing. Which we'd take a group of guys all by themselves, and generally the more experienced guys did that, and the guys that you had coming along training picked up the task of what was more or less you'd do for your mission readiness.

Then after Mercury, when we moved to Houston, and that's the next step, since we were still flying some Mercury, we got into doing. I wasn't really excited about this one, about designing the Space Center, our job and tools and all that. And that got to be one of the greatest things I ever did. That was quite an experience to go through, and sit down with what we'd

already had at the MCC and use that to design a really—a control center that you go anywhere in the world today and they all look the same. Every one of them looks like Building 30, which was the first or second building. I don't care where you go, they all look the same. I think everybody copied it.

You can go to an oil company who has a control center for just say the offshore stuff and the barges, see, it's the same type of lineup. Most people have a major display that has a kind of a map of whatever you're looking at. It kind of gives you—I mean, we used to kid each other, why you've got it, but even [Christopher C.] Kraft decided it was a good idea, because we argued that when we left MCC [Mercury Control Center] and got up here, do we really need that. Could we do it some other way? It wasn't just to be arbitrary, but what do you really need to do to do your job. We used to write our requirements and go to meetings and actually get into the damnedest arguments over all this stuff. I mean, we spent a lot of time doing it and from all of that effort.

And we had a lot of people here. I mean, we finally got—Ford Aerospace won the contract, and they brought in human factor engineers and stuff like that. We didn't even know about it, where you design consoles and design the people into the systems. It was really interesting. Those things that we put up, those [unclear] and those RGB screens and all that, and that scratcher thing for the real-time date, for the plot boards and the orbital, that was really state-of-the-art stuff.

Can you imagine how many pieces of glass that were put up, and if it was done wrong it started all over again. I don't know if anybody had ever seen that thing, but that was almost a piece of art, a work of art, to make that thing work that well. And we were the ones that designed that, of course, and wrote the requirements for it. The Flight Dynamics Officers and

the Flight Dynamics team probably did more to do that than anybody. The job we had, it was such a—it was a lot more difficult than anybody else's.

Then, of course, the guys came along, and as the systems got more complex, there was just some really—that changed. But at first it was a fairly simple system those guys had. They had inverters and plumbing and stuff like that. The only problem they had to do is realize how all that stuff worked in zero G, since nobody knew. But then it got more complex with onboard system fuel cells and all this stuff that we got into, life support systems, EVA [extravehicular activity]. That was something that became something that was dangerous. Still is, in my mind.

RUSNAK: Sure. What were some the key things that you wanted to see done in the new Control Center based on your experience in the old one?

LLEWELLYN: I tended to have a more conservative look on it than most people. I don't know where it came from. I liked to do things simple, so I tended to keep them the simplest stuff. There was a whole bunch of people who liked doing it more complicated, better displays and more things computed, and that always concerned me, because I figured the more you had to do, there was a lot more that you were going to make mistakes because the systems wasn't working that well at the time. I mean, everybody knows. You think you've got computer problems now. Man, we really had them. I mean, those things would quit on you, you wouldn't—and that's why they had all kinds of backup stuff from manual, especially the reentry FIDOs. We had all kinds of stuff. The last vector we had, I could almost compute retrofire times in my head, really. I mean, I've done it a couple of times, you know, just knowing the vector, just looking at the thing, just know knowing how they are. I know what it would have to be. It wasn't quite, but I

could get there within seconds, because that's all I did. I did it day after day. Not many guys had a job that good.

I mean, how many guys could walk over to a control center and have two 7094s working and push-pull and run data and get all the answers, because you didn't know what it was? You'd say, "Look, can I call them up?" They'd say, "What you got running today?" And this computer sup would say, "When are you going to run your reentry?" I wanted to run a bunch of cases. And, see, since it was real-time, we didn't have paper and all that stuff. They put it on the—in those days, it was really tough to run anything, because you had these great big, all these cards, and most people would drop them, and people would put the cards in backwards. It was just—I mean— [Laughter] And then you got piles of IBM paper. It's a good thing we lived in the United States; we had a lot of trees. [Laughter] I mean, you could run—I could have a pile of IBM—just to run a launch trajectory, the thing would be that high off the thing, just to pull off stuff to make a plot that would fit that on that white board. Then you had all the math aids to do all that stuff. So we really did a lot. Of course, all that became automated, of course.

But I got off the subject. Anyway, I tended to try to keep it simple [unclear], simple approaches is the right answer. I've always lived [unclear]. Once you get more complicated, it starts to be something else, you know. That was my thing. So I tended to do that.

Then a lot of guys were coming along, and, of course, the guys were getting out of school by that time, where even in those days knew more about FORTRAN than I did, because I picked up all that stuff working. I mean, we didn't even have a transistor in 19—I got out in '58, '59, so all of that came out to me and then the guys came along. The newer guys tended to get

more sophisticated in the kind of displays we had, and since they were doing that, I used them. So we got pretty good. We really did. We really pushed the state of the art.

The trajectory guys, the FIDOs and the Retros and the Guidance Officers and all the people in the—their equivalents in the IBM computer room and telemetry started developing a system of displays based on the hierarchy, and it really turned out good. So we got so we could see a lot of stuff, and it was that information flashed up there, and it was there and you just made your decisions on it.

That really turned out to be probably the best, probably the best thing we developed out of the system was to be able to fly these flights real time, and the tools we did develop, and the methods that we came up with.

RUSNAK: How did your position end up in the front row? Why there?

LLEWELLYN: It always was because we had to closer to the plot boards. We were the ones that had the real data. We were the ones that made all the decisions in those days. It was there and all the activity was there. In fact, I called it the trench, especially there in MCC, in the control center in Houston, because we were right at the bottom. I named it that because we had these P-tube [pneumatic tube] canisters, okay, and we would hit those things to get a piece of data. I mean, if I'd see something going on, I'd make a hard copy of it because I'd want to keep it, because then I knew what I made my decision on. It took that out of it.

That's one thing those hard copies did; it brought a lot of honesty into the business, because you had the data and you had it real time. It didn't mean people were dishonest. People tend to make mistakes and not want you to say that they made mistakes. What we did, it looked

like, because I was in the Marines, I'd been in Korea and all that, it looked like a bunch of 105 [mm] Howitzer canisters, especially in my area. It was just laying all over the thing. So we just called it a trench then, because it looked like all that stuff was falling in there. And everybody started calling it that. It was always a lot of activity going in there, so that's how it all started.

RUSNAK: Do you remember when it picked up that name?

LLEWELLYN: It picked up probably around GT-4. I think that's when it started. This is the first time I've told you, because I generally not—I've never said I did that. I'm doing it for this thing, though, because most—

RUSNAK: I was just getting ready to ask you that, though.

LLEWELLYN: I know it, but I generally won't admit to it. I make everybody else—just to listen to where they think it came from. [Charles F.] Deiterich got it, though, for [Eugene F.] Kranz. One of Kranz's meetings, Deiterich told him where it came from. Have you all talked to him?

RUSNAK: Chuck Deiterich? Not yet, no.

LLEWELLYN: He's a neat guy. He kind of was a follow-on. You know, if you look at guys that started in Apollo, he was kind of a follow-on. He went all the way through to Shuttle and still had an active role in trajectories and kept up with it all. Yes, that's where that came from.

RUSNAK: Well, it's good to get the story straight.

LLEWELLYN: It sounds as a certain amount of technical arrogance in this whole discussion about the control center, but it was no doubt about it, really where all the responsibility was and who were the top guys. It was us. There's no doubt. Because look at how many people that didn't make it.

RUSNAK: That's true.

LLEWELLYN: That were in the Flight Dynamics area.

RUSNAK: And certainly there are many stories surrounding the guys in the trench. Made up your own matchbooks, for instance.

LLEWELLYN: Yes, Bostick did that.

RUSNAK: Yes, he gave us a sample of one of those yesterday.

LLEWELLYN: That's neat.

RUSNAK: We thought so.

LLEWELLYN: Yes, he started that. And we used to have all kinds of things that we printed in our books like, "This is the property of the Retrofire Officer. If you want one, be one." "Please do not touch it," you know, like, "Don't mess with it if you're not one." That kind of thing. That kind of *esprit de corps* kind of thing we developed. We trained a lot of guys ourselves. We'd go in the control center at night and I'd call up the system. I'd be the flight director and get them all in there, and had the FIDO, Retros. We had them, and, I mean, it was really something. We really put them through it. The IBM guys, the Ford guys, loved it because it gave them a chance to run and test the equipment. We weren't doing anything different. I mean, they would have a chance, if we would come in at night and run trajectories and run, use the control center, then they would bring their people in and train them, too, because they had all—you know, that whole thing was like a beehive. You don't know it, but down in the bowels of that thing, it was just all kinds of people that made that work. That's one thing I did a lot of. I used to call it walking the lines. I wanted to make sure that all the guys I knew and what they were doing.

In fact, we used to call it—there was a big coffee pot, we'd call it "Behind Carnarvon," that big map that we talk about over in the left corner is where the coffeepot is, and we used to say we're going to Carnarvon, and we went over there to get our coffee. [Laughter] I mean, and I knew all the guys back there. You know, you had to, because they're the ones that made that work.

I'll never forget one time during Gemini we'd finally gotten to the point that Johnny Parker and I had figured out that that the onboard computer worked. It took us some time to get through that. So we came up with a way to monitor the reentry after the deorbit burn on the Gemini. We wanted to make sure—I don't know if you know this or not, but you're in orbit and that's one well-defined trajectory, and then you do the reentry maneuver, and what you've done

is that particular trajectory in space and time is drastically changed because now you're not in orbit anymore. You've completely redefined it in there. You're reentering, like a ballistic. And that's such a change, it's really a discontinuity between the orbit vector and the reentry vector, so you kind of start all over again in a matter of several, maybe twenty, thirty seconds, you had to get back.

We had the onboard computer for Gemini was really kind of neat when you thought about it, because it had a platform. We knew the platform. We could measure the velocity and changes in accelerations and all that stuff. Then you could actually monitor the maneuver, the delta V, the change. Then it would start picking up its new vector and it would come up with a vector of its own, inertial vector. Now, that's nothing these days, because that's how all of it works. But in those days, all that we got was tracking. The only way we did it was taking the radar data and externally finding out what it was by looking and computing the trajectory from the tracking data.

So what we wanted to do is to see how good that thing was. Could we get a look at it and make some checks on it, and could tell if it was go for reentry, okay. I mean, could we depend on the onboard solution? Because we always depended on what the ground said, because nobody seemed—same for the launch phase. The Gemini computer actually had a trajectory for the launch phase, but who would believe it? We kept looking at it and convincing ourselves that it was good. Anyway, that's what we were doing. So in order to do that we put a—did you ever hear about this ship thing that goes on about me and the ship? Has that thing come up, where I actually put a submarine under the tracking ship so that we would know where it was?

RUSNAK: No, I'm not familiar with that story.

LLEWELLYN: Okay. Well, it's in one of Kranz's books and stories. Anyway, we put a tracking ship between the retrofire and the touchdown point, and it was on a ship from Kwajalein. It was one of those that we were using down there to check our—we used to ship nuclear weapons down to Kwajalein and monitor them. So we used one of those ships. The Navy gave it to us or lent it to us. We paid for it or something.

In order to do that, to make a long story short, we had telemetry plus the vector, and we didn't have much of it. We had about maybe five minutes of it. What he and I wanted to do was take, once we got telemetry on and we got back at the control center, he and I would hit our buttons. I forget how many we had to do. It wouldn't take but so many hard copies. So he and I came up with a scheme that we had clocks, we would punch the button so we would try to get a vector every second during reentry, among all the other stuff we did.

So what we were doing, I got there and I got into that thing, and I guess I wasn't really thinking about how the ground system worked, because all I wanted to do was get the vector. So I came in—it was a real complex thing, and started hitting that button, and all of a sudden we heard the hard copy machine had failed. So what we had done, and that's when all of these—we did that and the P-tubes were doing it, and we must have had every P-tube in the control center in the trench. Once you start something like that, the thing automatically does it. It's kind of like a—it's really funny, when you think back. In fact, the M&O actually sent their people there to unload. I could hear them. They said, "Go to the retrofire and start unloading those P-tubes. There's none left." And they actually were taking other people's P-tube things and sticking them back in the system.

The bad thing about it is, it's so funny now looking back on it, so we got it and we were very happy, we had the vectors and we could do it, but because of that, we got sort of enamored with that, we couldn't tell anybody if it was good or not, but it didn't make any difference anyway, because it went to blackout. It perfectly worked. Well, it didn't work perfectly, but we knew what happened this time. Number GT-4 is the one that the computer failed. But we were learning.

But the funny thing about it, I went down to—the guy knew me. John Hatcher knew me, the maintenance guy, the M&O, the guy that ran the Ford part of it. He said, "John, you ought to go down and see this guys." So right after I finished my debriefing on the mission, we always did, and right after the mission we were so excited. I went down to where the P-tube room was, and I walked in there and they had the machine, they had two of them down there, these copy machines that made copies, and they'd completely had them—started field stripping them. They had them all apart, paper and—you know, it was before I even—we all know about printers and things going wrong, but this thing was really jammed up. They had this black ink all over them, and it was really funny. And the whole was full of it. I mean, it was—and I just thought to myself, I was so out of it, because we didn't realize the limitation. We were so concerned about getting this one second, that John and I completely destroyed the machine and the P-tube thing and the whole—because once they started doing that, it didn't make any difference if it had anything in them or not, because it was automated.

It was really funny. I look back and I thought to myself, I learned from that. I felt really bad, too, because these guys really tried, and they were so out of it, I mean, you could see that their machine, it was their own machine, it was totally ruined, and I'm the guy that did it. It was really funny, really to look back on it.

I only say that because it's so many people and so many guys that really made that thing work, because we got to using that a lot, that idea, being able to hard copies and real-time assessing the data. You just can't imagine. That's basically what people do today with work stations. We kind of started it, to drive that that way, to get that kind of display, because that really put us ahead of everybody. It could really make you smart. I mean, to have that kind of information and being able to process and getting something out of it, really, it's no way that—I mean, nobody had anything close to that.

When you had telemetry from a system and then you had—by that time we had such a good orbital determination system and such good equipment and such fine-tuned computers, it really was a hell of an experience and really good to go through it. I'm sure everybody learned a lot from that.

RUSNAK: I think Glynn Lunney was telling us that even as late as the Apollo-Soyuz test project, when the Soviets saw that system of being able to make hard copies, that they were so impressed with it that they wanted a version for themselves, because they had nothing like that.

LLEWELLYN: And you know, to talk about that, that was one thing I didn't think we needed. To go back to your question, I was more conservative. I mean, to me, I'm from kind of a backward place, okay, where I grew up at, and the only time I ever saw a P-tube was in Nackland's [phonetic] department store, okay. It all kind of little weird to me then. They were little small ones, wasn't very big. And that's what they came up with, because they didn't have any other way to do it. I mean, we didn't have a way to make hard copies except at that system, didn't have printers and stuff. Well, they had them, but not to take a picture like that.

No, that turned out to be one of the best things we did. In fact, that was part of our logs and real-time things is the hard copies and stuff we did and stamped them and what we did and this is what I made my decision on. It turned out good. The guys down there, in fact, our ACR [Advent Control Room] had somebody that did nothing but that. Here's the vector and here's the time and take a hard copy. It really was a help. That was one thing we never thought—and that was a use—like Glynn said, it just became real a tool that was developed, plus the real-time system.

RUSNAK: I wanted to ask you also, the control center for Gemini and later, obviously, was here in Houston. I want to ask you about the move itself. What did you feel about moving to Houston?

LLEWELLYN: I thought it was a good idea. I really did. I could see that. But then, see, we almost had two years of looking at this kind of thing, that, you know, you can do things at the speed of light. You don't have to be there. It took you a little time to do that, but remember you had the experience that we were dealing with people in orbit and it didn't make any difference where they were.

A lot of people don't really see that today. They call it "virtual." I don't care what they call it, it's there. It can happen. We can do that in time and space. Depends on how good your tools are, how you can do it.

So, to me, I thought it was a good idea. I thought it was a good move to—in fact, I like Texas. There was some discussion about could Houston support it and can you use the big plot boards and not little plot boards and all of that. I was one of the last guys who were doing it. I

still had one of my plot boards in the ACR just as a backup. But I really thought that was a good idea.

I also believed in doing away with the remote sites, starting off the Gemini, taking those sites and bringing them into the control center, have one solid control center. Everybody does it now, everybody, everybody. Even your big Internet networks, those huge things, they've got what they call a network operations center with all those server farms, routers, and has almost the same thing that people look at. I just saw one the other day, one very similar control center. They don't have as many people making decisions, because they don't have those kind of decisions, but they don't have that many different things to make them over. But it's the same idea, where you have all that equipment and stuff, and a lot of that stuff now is done by artificial intelligence and a lot of other things.

One thing, and it's a good point to remind us, too, from the Mercury stuff, look at how many people that were involved in labor-intensive network from a system of places to measure the trajectory that started at the Cape and went all the way around the world, Canaries and Kano and Zanzibar, and the ships and all the—I can almost see every one of them. That's just the ones that were manned. I don't know how many tracking stations and stuff we had. All of that stuff had to be manned, and each one of those stations had a lot of good people in them. When those went away, all those guys had to do something else. And that's what we've been able to do with the real-time systems.

So to answer your question, I thought it was a good idea, because I realized that if you didn't have a central system to make decisions and a group that all were in that system and they all understood it, it's very difficult to get anything done in a more extended—that kind of thing leads to more mistakes.

RUSNAK: When did you first come here?

LLEWELLYN: We got here right after John Glenn's flight. That's when I went into the flight dynamics period. It took me off of—I was working in—I think I mentioned last time, I was flight systems division or something like that. I was an engineer in heat transfer and reentry, building facilities, like that. Then I went in Flight Control Division, and we moved here. So that would be '62, I guess, March, February, about this time of year.

RUSNAK: So then you'd commute from here to the Cape before they had the control center here?

LLEWELLYN: Yes, we did that. We had Shepard's flight and all those right after that. We'd go to the Cape, and that's where we got immersed. We did that same thing up into Gemini IV, because we flew NS-1, Gemini I and Gemini III out of there. Some of that was done out of here. They had a backup system for III out of here. Then IV, we did it.

RUSNAK: So then did you work on the first two, the unmanned Gemini flights?

LLEWELLYN: Yes, I did all those. I did almost every one of them. Almost every one up until, I guess, Apollo 13. Had some position. Of course, we were bringing people in by Gemini. Bostick came in in Gemini. He was around for Mercury, but he wasn't on the console.

RUSNAK: Do you remember anything in particular from those two Gemini flights that sticks out in your mind?

LLEWELLYN: Good complicity. The onboard. Didn't have an escape tower. That bothered me from a manned space flight type of thing. We didn't have a way to get off in that early part of the flight. That bothered me. Which caused an awful lot of testing and ways to get around that and for the chutes. We had a feet-wet time and all that, and that's what we called Mode-1 aborts and it was left over from Mercury, where we'd used a tower, but we took the same kind of approach to make sure we could get that guy off of that thing. That really was—then we had, as we said, that system had its own guidance system also. It didn't get commands from the ground. It could. It couldn't fly itself.

We used to argue what day. In fact, one of the Gemini managers asked me one day, he said, "What day are you guys going to switch over from ground control, where you take your own vectors and let the inertial unit on the vehicle do it?" I told him, I said we'd do it the same day we'd do seat eject, because that was a real tough one. And what we tried to do is get him as quick as we could to a point that we could use the Gemini boosters and thrusters—I'm sorry, to make sure we could get off the damn thing and turn around for safe reentry.

Of course, we got more sophisticated with the onboard computer, and I spent a lot of time doing that and developing the system to monitor it and to understand it. Then that job left the Retros and the Guidance Officers and became another responsibility of the control center. They actually had a GNC [guidance, navigation, and control] that did that kind of thing, except make decisions on it. So those kind of things were the kind of things that were developed as we

left. That was something that came out of Gemini. We didn't do it right at the beginning either. It developed as we flew it.

RUSNAK: Also for Gemini, what about the expansion of the tracking network? Did that help you out?

LLEWELLYN: Oh, yes, it certainly did. Gemini was really a real big step, because, see, we had had Mercury, and not only just my individual and Glenn and the flight dynamics people there, we learned a lot in the computer people and IBM and Ford and all that. But everybody else had to learn a lot. Okay.

The ones that didn't learn anything were the people in Apollo. They did not, for some reason, pick up on the operation stuff and what was going on in flight operations. They tended to work on their own stuff, and, of course, that causes a lot of—when we got around to the early Apollo program, we really had a tough job integrating the operations and the real experience into the design people. Now, you always have that. I can see that in the kind of things that I do today, but it really was very noticeable and caused a lot of anxiety that we really didn't have to have. Of course, one was the AS-204, was a direct result, I think, of not having [Virgil I. "Gus"] Grissom's and [Edward H.] White's and [Roger B.] Chaffee's, is a good example, of not having the operation experience and the people getting in it at the time they did.

Because the Apollo thing kind of was, by its very complexity, was worked a different—we knew about it, but guys like I, working, we just read it and were interested in it. Gosh, when I went on to see the Vertical Assembly Building, I just couldn't believe it. I mean, that was just huge. I mean, you just can't even believe that tracked vehicle and you could see—I mean, the

first time I looked at it, you could see a kind of rectangular box on it, that was a tractor trailer. I mean, you just can't imagine what that thing looked like. But guys in those days, that was all being done and built and stuff, and being done with hardly any interrelationship between the Flight Dynamics people and the Operations people and who were doing it. I'm sure it was true with the support people, because people over there just were different people, and everybody doing Mercury and Gemini were busy doing their job. I mean, it happens. But that's a good lesson right there. I'm sure Kraft would agree to that. I'm sure that anybody else—that it was really a—we had a lot of catch-up. To me, it's amazing that we did as well as we did from '67 till the first flight in '68, going to the moon. Isn't it incredible?

RUSNAK: It was.

LLEWELLYN: To me it was.

RUSNAK: That's certainly an important lesson to have come out with. But we're about out of time for today.

LLEWELLYN: I appreciate it.

RUSNAK: So I think we'll wrap it up and we can pick up where we left off next time.

[End of interview]