ORAL HISTORY 4 TRANSCRIPT

JOHN S. LLEWELLYN, JR.
INTERVIEWED BY KEVIN M. RUSNAK
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RUSNAK: Today is March 13, 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 for joining us again. If we could pick up where we left off last time and start talking about some of the manned Gemini flights. We talked a little bit about the first two unmanned flights, but if we could start with Gemini III and what you remember going into that, and how you prepared for the mission, and then the flight itself.

LLEWELLYN: Okay. Gemini III was the first manned flight, of course, [Virgil I. "Gus"] Grissom and [John W.] Young. We were really at a turning point, because we had had some time to develop and absorb the Mercury experience and build a new facility in Houston in the meantime. We had seen the Apollo system move along.

I mean, at the Cape, now the control center, the MCC [Mission Control Center], which used to be, I thought was so huge, is almost small now in comparison to what was going on over in the vertical assembly building. It's a huge piece of equipment and stuff. Going down there and watching that develop at the same time as the Gemini going on, it really made you feel like, gosh, we've got do this right so we can get to that thing. I mean, it was almost like it was incredible to see how huge that building was and how huge the equipment was, the monster that

was going to take it out to the pad. I mean, nobody had really seen anything like that before. Now we're kind of used to it. But that was it.

We spent a lot of time at the Cape, because I was on the team that flew. We had one team at the Cape, the guys that knew it real well, [Glynn S.] Lunney and I and people that had been on Mercury. Then we had another team at the MCC that more or less were the new guys coming along, and they were more or less hands. We had a lot of new people we had to train. We had been going through a lot of training.

So this really was the first manned mission, and we had a new booster and a new abort situation, with no tower, which really was scary, because that tower really was, as far as manned space flight, it was really something. I mean, that thing made you feel better. At least, we could get it away from the fireball and give a guy a chance to get out. This thing had seats, and so that made it difficult for, say, a pad abort. So we had all kinds of tests and stuff to redefine that. We had what we called a feet-wet time, that they could eject and get their feet—I mean, get in the water, because we wanted them over the water. So that was new.

Of course, the whole abort phase was different. We had a lifting entry vehicle that we were learning. We spent an awful lot of time on the on-board computer trying to figure out what it was. But at that time we were really—that was just almost a mystery how that worked. But it was important to us, as a flight dynamics team, to know exactly how it worked. So we probably spent more time on that. Of all the flight controllers, we probably were the most intense on that. So I don't know how to say it any more than that to me was really a brand-new, almost a completely new dimension that even when we'd flown Mercury, the guys that had to take that over spent all kinds of time in getting briefed and going places on their own time, I mean, on the weekends. We'd come in and have mission rules meetings on Sundays, and work

that thing through, so we would know exactly, almost memorize the launch phase. So we knew exactly what all the people were doing and almost timed it, knowing when seven minutes was. I mean, we just did it so much. Anyway, that's how we did it, because this time we had an on-board computer and we were still learning it.

By the way, you know, nobody even had one of those things. That was IBM [International Business Machines]-made and we'd go to see it. I'll never forget, they had these women out there and they actually had these big like highly magnifying instruments that could look down in it. They were stringing these little donuts, and that's how they made them. I mean, you can actually see them making the memory. That's kind of like what's the hard drive, and those things goes—because they had a memory from a magnetic sense and they were isolated. That kind of gave you ones and zeroes, but that is so far back that nobody—I was just amazed at it, and plus the fact she could load it. I mean, they had tapes. I mean, you could load launch phase and take it as like a cassette. It's almost like the ones that you see now for the early music cassettes. Maybe somebody got an idea from that. But that's what it was.

Then there was a lot more responsibility on the ground, because not only did we have that computer now, but we had the real-time system and then we had a backup system. The flight dynamics people had something, what we call a flight dynamics SSR [staff support room] that I kind of ran, because most of the stuff that had to be studied in those days before rendezvous and those things, for the reentry maneuvers and backup and running cases based on your latest vector on what kind of drag miles you had, and the flight dynamics people were kind of like—before they got a real trajectory organization at Goddard [Space Flight Center, Greenbelt, Maryland] through the network, we kind of were the ones that were checking the network out. Don't get me wrong. We had a lot of people helping us. But when it came down

to the real-time data, since it was only in that computer, we were the only ones that could get to it. You know, not everybody—in those days, the only things you got were paper and some readout on a console. I was at the console. I'll bring you a picture of that, and you can have that, the retrofire officer's console at the Cape.

Anyway, so based on that is a background to this thing. We really had a problem, too, if we did have a failure of some—would we switch over to the on-board guidance system as a backup, because the project office and people wanted to do that. But being in the manned space flight, you're not going to switch over to something you don't understand. Okay. That's a rule that we made. Hold on to what you got. If you don't know what it is, don't put yourself in, because that just gets—it's like messing with those phones. You don't have time in real-time to figure that out. You've got to know the systems, and they've got to be good or you're not going to switch over when you abort.

That was a big problem, and it put a lot of pressure on guys like the FDO [Flight Dynamics Officer] and I, because we had abort lines. The abort procedures, we put more of that in the crew's hands now, we didn't have it from the ground. FDO had the on-board switch for the shutdown, but we didn't fire anything from the ground anymore. We had abort lights we sent, but nothing like the Mercury. Of course, that was fairly simple, too.

So anyway, we had that to do. Now what got complicated is, not only the manned, manned space flight, I think, did probably the U.S. better to get us in space than anything, because we really, that was our thing to do is to take care of that, to make sure this thing is at all cases the guy had a chance to get out. So we spent a lot of time. I don't want to take too much time on it, but that was what bothered me more than going in the Gemini.

I don't think it bothered most people, but I think it bothered flight dynamics officer and I. Certainly Grissom. He wanted to use a paraglider. He tried so hard to do it, and he kept messing with it, but it just never would work. The configuration of how the cables came out of the Gemini, it just was not—too many things could go wrong to depend on that. So we didn't use that, and used it as a reentry vehicle, which you had to be very careful with, because remember they had those two legs where the slides came out of it. The hard points, and they were right by the seats, so you had to be very careful. You wanted to make sure that you were in water when you hit, because those things landing can be catastrophic. So we had that to deal with, as a result of the seats. I mean, we had the seats in that. All that came together.

Anyway, that was it and it turned out that we had a lot of personnel changes. We had a lot of new astronauts coming in. I don't know if anybody else knows, that was an adjustment between the flight controllers, the guys on the ground, and the new crewmen. Since they had been with us in Gemini, and since there were so many new people, we'd gotten two sets now of new astronauts, plus the old set. Some of those guys were going away, but the flight controllers, most of us was still around, plus we had so many new ones.

We had this really big remote site effort now with more vehicles and more complicity. The number of the remote sites and the complexity of the remote sites, because, see, now we had not only the Gemini and all of the things that went with that, the thrusters and the new fuel systems and all that, you had the Agena vehicle that we had to rendezvous. All of that came right after Mercury, right into Gemini III.

That was the one that also—that's when people stopped naming them. I think Grissom, probably, they had much to do with that. He called his *Unsinkable Molly Brown*. Remember that stage show? That was going back to MR-4 [Mercury-Redstone 4]. So that was his thing. It

just got to a point that the best thing to do was not name them anymore, the *Liberty Bells* and all that. They decided we just won't do that anymore. But he did call it that, and everybody else called it that, except the press. So we had that.

Then we had the adjustment on the remote sites. Has anybody talked about that? Kind of a rebellion between people like Carnarvon and [Charles C. "Pete"] Conrad and a guy named Dan Hunter. They'd all get on the loop and talk about that. The guy in the loop was listened to by everybody in the world. I just couldn't believe it that we actually—who was in charge is what it was all about, and it went on, and it even spread into the mission control. We argued among ourselves with it. But we finally got over it and it went okay. After that we didn't have much trouble after Gemini. I don't know if anybody ever talked about that. That was really something. That really got everybody. Right before the mission, too, a big argument just before liftoff, like two days. The last sim.

The flight went perfect for me. We had that glitch with the computer, but again it was the first time we used it. So that went out of the way, and it worked real well. Then we had MR-4, which was real close together and it was the first EVA [extravehicular activity]. Nobody knew about it except maybe two or three guys in the control center, the flight director that was on the EVA, the launch guy. I think the only other guy was me. I don't think anybody else knew it.

I had to know it, because I had to run the one-man reentry. In case we couldn't get him back in we'd have to look—and all the guys were wondering why I was doing that. They were saying, "Why are you doing that? How come you're running that kind of stuff, and taking the guy out and changing his CG [center of gravity]?"

I said, "Come on." I said, "I'm just peculiar that way."

They'd say, "How's he going to get out?" There were questions, and I thought, you've got to figure this out if this keeps going on.

So we did it, and then just before liftoff they told everybody. But they wanted to do it, the press at that point was really—we were kind of not adjusted to it. I mean, they had started, as the press does right now, they'd started being very critical of [Christopher C.] Kraft [Jr.] and of the operation itself. We were fairly honest with them, and probably something that that press had never seen. We were real. I mean, most everybody was an engineer, and that must have really ruined them, because we all told the truth about everything. I mean, they couldn't believe it.

So we had to adjust to that, and I think Kraft did a good job with it. I think he was kind of thought about it a lot, like anything else, and he got to the point that the press really liked him. I mean, he's the only guy I ever knew the press really liked. I think he could have been President if he wanted to. He'd tell them, I mean, "I'm here to get this job done. I've got a hell of a big job. If you're going to sit here, if I'm doing something and I'm not doing this, and we don't give you the right briefings and stuff like that, then I'm doing my job wrong. But you can't be saying things about me and my people. I've got a little house to live in and friends. Everybody knows everybody."

It was really good, and that's how we did it. He kind of, by the time we got to Gemini, he had a press briefing, he did that. He started that whole thing. In fact, he started—JSC [Johnson Space Center] started that, the whole world does it now. I mean, I don't care if you're at JPL [Jet Propulsion Laboratory, Pasadena, California] or where you are, everybody has, after you do a press briefing, so you go answer, it's run the same way. The press does the same thing. But he started that.

He used to pick the guys that he was going to—when you had to go, he would tell you which was going to go and what he wanted to talk about. So that was done at that point. That was the first time we really sat down and looked and kind of met the press and answered their questions real-time and told about reentry. I mean, I must have gone to almost every one of them and I answered all kinds of questions. But it went well.

Then, of course, the next one was Gemini IV. That was really a good mission. He [Edward H. White II] had a hard time getting back in there and that kind of thing. We had a problem with the real-time system. The radar beacons were, the beacons on the spacecraft was good, but the way we looked at the data, we looked at it backwards and it gave us really strange-looking orbits. But we had the computer from Goddard and they passed us a vector down and we got back.

Then we lost the computer on that one some way. We were updating it or doing something to it, and it quit. We had to do a rolling reentry. We decided to do that. In fact, [James A.] McDivitt and those guys, White probably pulled more Gs. They were last ones pulling out of Gs. They pulled probably nine and a half or ten, maybe more than that, I forgot what it was. Because you roll when you came straight in.

Then we had [Gemini] V. Let's see. Another computer deal. That was [unclear]. That was my time in the—that's the first I'd really gotten whacked around. Overlooked that in one of the systems. Terra turns a little bit more than 2π, 360 degrees, depending how you measured. It added up and we never did—every time we went over it, we just clocked it as N, but it was really because of the number of times that we were off and the computer was looking at the wrong target point. That was the last time that thing happened.

But in general, though, the on-board computer and the platform and that capability was developing the operational, the systems and the philosophical, and whatever you want to call it, of dealing with a new system, and the crew, too. I mean, all of us together had to work on it. We spent a lot of time in simulators and running data on both of them.

I told you the one about the ship last time. That was for [Gemini] V. No, VI. So it took us some time to get there. Then it became more of a—I kind got out of the feeling that it got so complicated in launch phase, because you stopped, you tended, the way it used to be, I was so glad to get by certain points in it that as a result that, like get to orbit, and then we get that—it seemed like my idea was the higher we could away from Earth, the better it was, because we had a lot of time for it to fall, you know what I mean? It's like flying airplanes, the best thing to do for an airplane, if you get in trouble, is get as high as you can, right? You don't want to get low and have trouble.

But what happened was, and I'm sure that Glynn, [S. Lunney] when you talk to him, was the complexity that we got with things like doing rendezvouses and that docking business, and making sure all the vectors were right, and what system we were going to believe in again. Do we believe the on-board system? Do we believe the computer or do we just believe the visual, the strapdown and fly the hori—It was all kinds of things that we had to decide on.

All of those things had to be simulated so we could tell just exactly which one of them was wrong. It seemed, at first, when we first looked, it was lucky, because we had more data sources. But the problem with the data sources, they themselves are subject to error and human mistakes and just the way things are.

Now it's no problem because all the computer—you can't hardly do anything to a computer. I mean, I got one that I'm riding around in my front seat, because the hard drive's

gone on it, and that thing is bigger than the 7094s. You know what I'm saying? I can carry it around with me. It's just incredible to have.

But in those days, I look back on it, it was just difficult. In fact, the real-time system had so much it had to do, it really couldn't do the stays anymore, and that's why the ACR [auxiliary computing room] became so important, because they ran a lot of stuff to check the real-time system. At one time there was a little bit of professional jealousy between the IBM guys there and up in Building 12. But after a while they kind of—in fact, the guy says, "What are you getting from the ACR on that?" It was good. What is the differences?

The guys from the real-time system spent more, looking more at the stuff we were doing. So whatever we were doing, they wanted to make sure that they were right after that phase with some end thing and that we were right. It turned out really good and it was all based on that idea of, the new idea of information and the stuff that we're all going through it right now. The idea of the information age, the computers, the Internet. I mean, that's the kind of—just like we talked last time, those hard copies were kind of like Internet. It was the way you could get your data, and it was a way to that you didn't have to spent a lot of time in libraries or stuff like that. It was right there in front of you. You could run the data and look at it. So that's what I'm saying.

Then we got to the rendezvouses, and those things got to be so complicated for the flight dynamics, because we did the targeting for the on-board system for rendezvous. The Gemini vehicle had to have the right knowledge of the Agena orbit, and to do that we had to load that thing in there, and that's how it computed its solution for rendezvouses. We had that to do, and then we had the one from the real-time system solution. Both of them were integrated, and thrust vectors, and I kept learning. It was good stuff, which caused more complicity in the real-

time system because it took more memory, and it was kind of like the problems they got in comm here. They had to stop doing things. Some things the machine, when we got ready to do all that, they wouldn't process telemetry data, any of the housekeeping stuff, they just let that go until we got that.

Anyway, that kept us busy, it really did, constantly keeping up with the system, constantly, night studying, and during the day talking to other guys that had similar problems in the organizations and other stuff.

Here's an interesting one. We were having trouble with, of course, the reentry guidance, and to me that was the biggest thing we came at. The rendezvous was important, but a rendezvous problem is just a reentry problem without hitting the Earth. It's the same thing. I mean, you do the same thing. You do a maneuver and you reduce, pulls you down to where it's at the surface of the Earth, and that's how you do it.

The thing that I wanted to do, it was so difficult to make that computer—that you could trust it. It didn't mean that it wasn't all right like it was, but when you put your life and the crew and everything, I mean, we'd gotten to the point, by the time we got to the Gemini V, that I wasn't worried about anything on the Space Station, I mean, on the space itself, because the crew and all of us had enough sense to know which was okay. But you knew damn well that you could look ahead, and that I knew for the entry, the lunar stuff, you could not depend on a human to do that because of the Gs, because I'd already done gotten in that.

We had one of those accelerator things and I had gotten in there to see what a G profile would look like, and it was just incredible, because the onset at a quarter G, the onset was four, and you had 4 Gs, you had that for like three or four minutes, then you spiked up and you came back off. It was a long—because, you see, you got to slow down. The lift factor spreads it out.

Instead of going right up to a complete stop, it just kind of slows you down. You still take the acceleration. It's just over a longer period of time that a human can survive that. I knew that. We were looking, that's why I kept working on the on-board computer. I had some really good guys help me, too. I mean, that wasn't by myself. I mean, everybody, it wasn't just one person, but I was really, since I knew that that was going to be the next thing we had to accomplish.

I mean, you think back in 1966, what the situation in them computers that we had. They wouldn't stay, it wouldn't take any of them any time for them to go down. I mean, seriously. I mean, I've seen them standing, those computers Sups, the supervisors, standing with go tapes, and that's the ones they loaded for the system before liftoff. I mean, practicing and everything. I've seen a lot, I've seen four or five in a line with each of them, and if they didn't go, they had to go back and fix them. That's kind of like two days before liftoff. That's hairy.

So that's the thing I saw and that's what I worked on. Plus all the other stuff we had to get into, early reentries and more systems going bad, and more people thinking they were bad and they were really okay, you know. But that's it, it was really a learning experience and very, very—it completely captures you and you're immersed in it.

I can't remember anything about my family or home. I can remember something. I can't remember anything except that. I was that much absorbed in it. I think a lot of people were. I think it kept doing that until Apollo. I think after Apollo we finally looked around, we actually had children and families, you know. But we spent lots of time doing that.

The guidance problems where we had, where you had to track the—and then you'd lift off and try to do M=1 rendezvouses and all that. Even though I wasn't a rendezvous guy, I had to know all that stuff, because all of those trajectories we got into between the time that the one that you started from to the time you ended up with, you had to reenter from all of them. I

mean, they all had to be safe and they all to have a place and enough time, if you did have a problem, that they could break away. That was really good training.

By this time I had seven or eight more retrofire officers that I worked with, so we were building that up. Some of them were working on Apollo stuff, that I deal with. That was good, because I worked on both missions, and some of them worked on the Gemini.

I don't know if anybody ever talked about the Agena stuff. You want to talk about that, the Agena missions, and the first one that we really launched, we never saw it. Kranz went on and on, and said that he was hoping Carnarvon would see it or something like that. I knew he wouldn't, because I saw it on my plot board. They got that, but anyway. Then we had to fly that mission because we didn't rendezvous, we rendezvoused with a ball and that kind of thing.

Then we had our first docking, and that was [Gemini] VIII. That was an exciting thing, because we got all that done, and then we had [Neil A.] Armstrong popped the RCS [reaction control system] rings early to get control of it there. It wasn't Agena. It was a struck thruster, and he finally got that done. Anyway, that was quite a reentry. I was on the console, and I did that whole thing from the time it had clocks that were not loaded.

The reentry, remember, we came over Red China, because I could see a ground track. In fact, I told [Flight Director John D.] Hodge, "You'd better call somebody and tell them that we're going into the South China Sea." It kind of changed a lot of our procedures for reentry, because we started looking at when the last time we could see them and get what we called the IBIs. If we could get what his accelerometers read, we could give a pretty good idea, based on anything he did, we could do the computer. In fact, if it did a real reentry we didn't know where it went, because if we knew exactly what his accelerations are.

The other one, if it didn't work, since we gave him his backup bank angles to fly, so you could fly, he could roll over and hold it in reverse bank angle and use half, where you can get halfway up the lift thing, we could do that and we couldn't know where that was. So it was important to do that.

I really was surprised when I looked at the telemetry coming over Hawaii after this thing happened. I was wondering, because Armstrong was in the orbital mode, and he had to pull, with all that going out, he had to pull that cassette out and kind of boot up the computer in less than twenty minutes. Because he and I had a big argument over it, about the on-board computer, because he thought he could fly the thing better than the computer.

A lot of those guys, you had to deal with that. I mean, to be like Armstrong, I mean, you had to have an ego. I mean, it was no doubt about that. I mean, he was very bright, done a lot of stuff. I mean, X-15 blew up under him, and it didn't bother him too much. That's got to be wow.

So we had our big arguments with him, I did, over this whole thing, and spent a lot of time with him personally going over the on-board computer and how you flew it and what was it about. Obviously when that happened, he knew he was going in the sea, he had figured out, just like I did, that his best bet was knowing exactly where he was. So that's what we did, and that turned out okay.

That was one of the best things ever happened to me, because all that stuff that I had done and work, not on me, I mean, we, not I, the whole, everybody that worked on the entry stuff and on the on-board stuff and everybody. It worked so good, because those planes came right over them and they were right there. In fact, the first plane came over and I talked to—

what was his name? He's a general now. Who was Armstrong's second guy? What was his name?

RUSNAK: Dave [David R.] Scott?

LLEWELLYN: Dave Scott. Scott said he saw them come over, and they were already there, and they were waving at him and all, they just came right by him. He didn't know the guys had dropped them in the water, dropped his front SEALs. When those guys came at the water, both of them almost jumped overboard, didn't know what the hell that was. It scared them to death. It touched them on the back because we were helping them put the flotation down. So it was really good they were right there. That made me feel good that we could actually do that.

Especially then, because the Vietnam War, that's where there was a lot of that, we hadn't really gotten into that thing with [President Lyndon B.] Johnson yet, but it was really close to it. It was right in that same area.

That was VIII, and then there was IX, and the 76 [Gemini flights VII and VI] was good. That was a good mission, where we had both of them up at the same time as a result of that Agena thing.

RUSNAK: How did that work with having the two craft up at the same time with the controllers in the control center, that type of thing?

LLEWELLYN: It went just perfect. It really did. It was kind of like we'd already practiced it. It really went well. That thing went so well. By the way, it's the first time we could see a picture.

We could actually see the rendezvous and that was just incredible to me, to take pictures of the thing docking. Because up to that time we'd always made up—we had to think about how it was and perceive our own perception of what was going on there.

RUSNAK: Which shift were you on for that? Do you remember which craft you were working?

LLEWELLYN: I was on both of them, because, see, we reentered one day and then reentered the next the next one. For both of those I was prime. But I was on both floors. I was aware of both of them.

RUSNAK: The latter Gemini missions were known primarily for the EVAs, and particularly difficulties they were having on some EVAs, until finally the last flight where Buzz [Edwin E.] Aldrin [Jr.] was able to successfully incorporate the different training methods and that type of thing to do a good EVA. What do you remember of those flights?

LLEWELLYN: I remember that that was very difficult. EVAs are very, very bad for reentry people. Because we never had one on that, I felt like it was safe. They all seemed to be right, or borderline. Something would happen, you know, [Walter M.] Schirra—I mean [Eugene A.] Cernan's deal and then they couldn't White back in, couldn't get the hatch shut. The stuff with the high altitude was what's-his-name and [Charles C. "Pete"] Conrad.

I wasn't an EVA guy, I wasn't a suit guy, and I knew them all and I had a lot of respect for them, but it just seemed like every time we got a guy outside, it was very dangerous. It was the same way with Apollo, and it was the same way with the last time I had anything to do with

the Shuttle. I mean, to me it's experience. It's something that you've got to be very careful with. I don't think anybody will ever feel comfortable with it.

I don't know what the Mars things will be like. The Space Station that we had, that's going to—who knows. It seems like that people do EVAs better now. I'm not in the control center anymore, but it seems like to me that you can get behind.

But, see, without all of that business, we would never have gotten to the place to have the—I think really the—what do you call it, the capability, being responsible enough to say, yes, we can go to the moon the second shot with Apollo. With the kind of luck we were having, but we felt like that we had the knowledge and the confidence that we could do that, and it was really a great experience.

It was probably one of the better ones that I had with Apollo 8, to get that thing off and do that. I mean, that was really something. But all of that Gemini stuff that we talked about, the reason I haven't gotten into some of the other stuff we did is because my mind has kind of with that, all of the stuff that we did with the on-board computer and the reentry, and I don't want to think that's the only thing that I thought of during that period, but it took a lot of my time.

For example, the lift factor stuff, we had real trouble trying to figure out that and how to do that. A guy called me from Tennessee, called me one morning, he said, "Look, I know that where you are, you may not, but I found out something running some tests." He says, "The lift is a function of the trim angle, off of trim."

I said, "Yes, I know a little bit of that."

He said, "But you got to know where your CG is," and that's something we didn't do. We knew where it was, but we didn't have a way to compute the trim angles to go into the computer, and we had to change that software so the on-board computer would know where the

CG is when we loaded it, whether we gave them the numbers, because they had no way of knowing it. I mean, that was one of the first things.

I mean, that was such a, almost a—I mean, who could have thought of that? A guy just did it. I mean, some guy that just called me up one day. Of course, we had to have a lot of meetings, but everybody agreed that that's how to do it and we changed and then everything started doing better.

Same thing with the Apollo. You have the thing, the on-board computer does not know where the CG is. They still do it for the Shuttle. I'll bet you they still compute that. That's part of the go-tape. I'll bet you they still do it.

RUSNAK: What do you think the key items were that you learned from the Gemini Program that were directly applicable to Apollo?

LLEWELLYN: I think we did a whole bunch of stuff. I think the step in the information that allowed us to do Apollo, the on-board computer and being able to navigate and set your platform and all that, and understanding how that worked, even though it was a lot more sophisticated and we didn't even know it was coming yet, but being able to go through with Gemini really helped me and it helped everybody, I think. That's what I like.

But as far as the other stuff, I mean, I don't know what to say. I mean, look at the fuel cells, the tape recorders, look how much that had changed. The whole business about being able to have electrical power and understand that and not have the kind of problems we had with Mercury, and the environmental control system that we had, the more flexibility with maneuverability, being able to do maneuvers that restart an engine in orbit. That's good.

I mean, that's something that not many countries could do that. For a long time, the only country that had a restartable upper-stage was the U.S. Nobody had one. We kind of gave it, let the French understand it, and the Chinese finally got it one way or another. Who knows what they did to get it, but they had a restartable upper-stage, but a lot of people didn't have it. That's something that came out of the Gemini Program, those hypergolic fuels and stuff. So it's hard to put your finger on it.

The heat shield, that's another thing that we did, heat protection scheme was a lot better, a lot lighter. We went through all of that land landing thing, even though we never did it. We spent a lot of time with parachutes and skid tests and all that stuff. But that was also a good—that wasn't a waste of time.

RUSNAK: Some people suggested that NASA might have been able to get away with not having the Gemini Program by having more early Apollo flights. Do you think the program was necessary?

LLEWELLYN: Oh, it had to be. It had to be. It was too much of a step to not go through a good solid knowing what you're doing in orbit around the Earth. I mean, you had to do that, and Apollo wasn't done for that. The Apollo had such big engines. I mean, gosh, what was the reentry burn for Apollo? Ten seconds or five seconds? I mean, can you imagine an SPS [service propulsion system] engine turning on for that little bit, as big as that thing was? That's scary. That was almost just like a burp or something, that was nothing to it, because it was going to have to burn a lot. That's how you had to get in. I mean, man, you turn that thing on, you had about fifteen minutes to .05-G a blackout. I mean, it came in from a reentry standpoint

for a lot of reasons, a big engine around the Earth's orbit. Look what the trouble you can get into.

But we had to have it there to see—we had to go through the same thing then as we did so we'd understand that, yes, the physics work here as it well does the Moon. Everybody's got the—what is it? Principle says that all physics are right. Wherever we go there, never been any different one, but it's good to check it out before you try it.

No, I just don't see how that we—no, as far as the progression of talent and information and experience, I think the real question is, can anybody do it again in ten years? It's not how you did it; can you do it? I mean, that's the real question. Maybe you'd have to go back and you're going to have to go back through some of that stuff to even go to Mars.

But, for example, I was just looking at some of the Mars stuff. There is nobody, and I see them doing it, that direct to lunar—Mars entry is crazy. You've got to have a Space Station, you've got to be able to do a breaking maneuver in orbit and then come in—you're not—from Earth orbit. You're not going to carry a reentry system that you can do a direct return to the Earth.

In *Scientific American* I just saw that same—and that's a good magazine, but who's telling them to do that? Who's in charge of all that? Because that's not right. You're not going to do it. I told George [W. S.] Abbey, no way. I don't think we should do a direct lunar reentry either, not unless you're just going to bring in materials. You might just bring in material and with a big heat shield and kind of go through a G profile, but not people. So that's something we learned for the next stuff we do. We learned that.

RUSNAK: Who were some of the other people in the Gemini Program that you felt really made a contribution to the whole learning process and that helped prepare you for Apollo?

LLEWELLYN: I think that the guys that—certainly there was some real good systems people that were good. A lot of the LM [lunar module] guys, I remember, were good. There's a guy named, he's not even a NASA guy, his name was Harry Smith, he worked for Grumman. He was good. He's dead now. It's too bad you can't talk to him. Really good in terms of understood the environmental things, the housekeeping, things that keep people alive. That was really a lot going on. Look at the problems we had with the atmosphere and the Shuttle, the first one. I think that accomplishment on how to live in space was probably—I didn't have that much to do with that, because I was more of a trajectory guy and fixed it so you could live in it, but the idea of being able to get—look how small Mercury was, and then the Gemini wasn't a whole bit bigger, but at least it was big enough that you could move around in it. That came a long ways just to be able to cope with it and to feel comfortable with it and have the confidence to do the next thing.

I can't remember specifically. There's a whole bunch of guys. I think the talent really improved in the Gemini. The guys by that time they'd matured and knew what the code business was a lot better then, which really helped for Apollo. I don't know how else to answer it. It's a good question.

The other thing is, too, the other thing we had to do on the ground is manage a fairly sophisticated, almost by a magnitude, sophisticated between Gemini and Mercury was really big, the type of things we had to do and the type of things we had to know about. I mean, stretching the envelope of being able to do maneuvers and comfortably doing it and going way

out and coming back in and all of that, that was getting us ready for Apollo, because Apollo really did spend—my biggest thing with Apollo was trying to understand the physics of what we were doing. That's what I had to get my mind where the Moon was and how we really were doing that so I could think about it. You know, what was the environment like, and it was so harsh and so much unknown in those days when we first went. Guys was arguing about especially landing there, that was a real thin, tenuous dust, and the thing would sink. They came up about a year or two before we finally—when nobody really mentioned that, somebody did. That's why they had those little things on the feet.

But that's the thing, I think, the big difference between Apollo and Gemini was, because we were pretty comfortable about doing the operation and the man in it and understanding how to do countdowns and how to get ready for a mission and all the pieces. We'd come up with a lot better way to make sure that we had the right information and we had a book and we had it all in one. It was documented well and you could—all of those kind of things that make a well-managed organization, we developed doing the early Mercury, Gemini, and Apollo at the same time.

So that project management that, I guess, at one time NASA was probably the best at. I mentioned this last time, after the Apollo flights we couldn't do any wrong. Everybody was saying, "That's the way to do the world. The world's going to be done like NASA did the Moon flight." Yes, we did them, but it turns out that that doesn't extend into socioeconomic problems. It doesn't extend into all the cultural stuff. It just won't work in that. We did good managing the high-tech business, but that's the only thing you can manage using that style. So I think, to answer your question, I think the answer is to be able to understand and manage a fairly complicated system.

RUSNAK: It sounds like a good lesson to learn from that.

Well, we've been going about an hour, so why don't we go ahead and stop here.

LLEWELLYN: Okay.

[End of interview]