NASA JOHNSON SPACE CENTER ORAL HISTORY PROJECT
ORAL HISTORY TRANSCRIPT

JOSEPH F. SHEA
INTERVIEWED BY MICHELLE KELLY
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KELLY: The following interview of Dr. Joseph Shea was conducted in Weston, Massachusetts by Michelle Kelly on November 23, 1998.

SHEA: What we were trying to stress was rigor in the program and what is the real requirement. Finally, I don't know, maybe three months after I got to Houston, up until then we never had a chance to test the heat shield material, but we finally got an arc jet that could raise the heat shield temperature up to 150 or so degrees Fahrenheit that it would see on the heat of reentry. But before that, we also could cool it down to the minus-150 [degrees Fahrenheit] that it would see when it was just looking out at space and not at the sun. Sure enough, the heat shield material started to crack and craze when they ran those tests on it.

So the heat shield people came to me and said, "We've got a problem. We need a new heat shield." They didn't know how to do it. How much money? Oh, God, at least 60 million dollars.

So I thought about it, and I said, "Well, why is this the requirement?" Well, the spacecraft could be in a given attitude going out to the moon and coming back, one side was always facing the sun and the other side always facing cold space, you'd have these thermal extremes. I said, "Why the hell does it have to be in one attitude on the way out or for any period of time? It's out in space. It could tumble. It could do anything." So I came up with what I called the "rotisserie mode." I said, "Let's just spin the spacecraft slowly, once a minute or less." It turned out the length of time it took for the temperatures to change was hours, so it didn't make any difference.

So, once we put the rotisserie mode in, I think the total change in temperature on the heat shield was maybe twenty degrees at the most. So the astronauts, they all were going to get to be—the control people said, "Oh, we can't handle the flight control." I know enough about those subjects that I said, "Yes, you can. Go back and study it again." So we put the rotisserie mode in on the way out and the rotisserie mode on the way back, and saved both the time of the redesign and the money of the redesign.

KELLY: Absolutely. Where did you get that information? Was it from your work on the Titan?

SHEA: All you have to do is think about what's the real requirement.

KELLY: You mentioned that there were some other problems. Can you think of some other examples where you went in there and you thought, you know, this is something that we don't necessarily have to redevelop or redesign?

SHEA: When I got to Houston, which was like a year after the lunar mode decision had been made, there was no design for putting the command module and service module together as there would have to be in order to dock and separate and so on. And when the guys got working on that, oh, again, we had a control problem, and again we have structural problems, it's going to be too big and too heavy. I figured that they were probably overstating the case, which they usually do, so I said, "Go back and rework the problem again."

So they came up with—what we finally had was a stable system as Apollo 13 showed you had the ability for the lunar module to push the command module back to Earth in case you had a problem. The weight of the connection that was required to do that wasn't that heavy, so we could afford it in the weight budget. So that's a second example.

KELLY: And luckily for the crew on Apollo 13.

SHEA: On Apollo 13. I would take some credit for the Apollo 13. And there are other things, silly things. You want the inspectors to be rigorous up to a point. We had the whole spacecraft assembled at Downey. The thing we didn't have was the electrical power system, the so-called fuel cells, which wasn't an invention, but it was a new application of an old idea, and they were being built up at Pratt & Whitney in Hartford, Connecticut. Three weeks in a row, you'll find in the notes, "Fuel cell leak because of quality problems. Fuel cell leak because of quality problems." I finally asked my guy Tom [J. Thomas] Markley to find out what the hell's going on up there. You know what the quality problem was?

KELLY: What was that?

SHEA: The shipping container for the fuel cell was not painted the right shade of NASA blue.

KELLY: Are you kidding? [Laughter]

SHEA: I am honest to God not kidding.

KELLY: How did you resolve that problem?

SHEA: I asked for colorblind inspectors.

KELLY: I like that. What a good idea.

SHEA: But it's an example of overkill. Things can be very serious, like the heat shield and the docking mechanism, and then can be just absolute trivia and junk. You had to be able to separate that out in your own mind, which was important, which wasn't. That's why the spec is so important, the trace. Remember we talked earlier about the traceability of the requirement up to the top level spec for each subsystem so you knew why the requirement was what it was. That's the biggest reason for doing the spec tree the way you do it and so on.

KELLY: And so you know what specification is really important and those that are not necessarily so critical.

SHEA: Well, in principle, you only put in the important parts of the specification.

KELLY: And I guess, conceptually, if you put in too many specifications, as in the instance of the NASA blue color, your cost will be driven up.

SHEA: Well, it's inevitable the further down you get in the tree, the more and more numbers appear, and probably the less important each number is. But now you're handing this guy a contract to develop a system, and so the numbers come with the contract, and somebody has to understand the origin of the numbers.

KELLY: And how do you determine at what point the specification is too detailed or not necessarily critical to the system?

SHEA: Somebody has to be the system engineer, who understands the system well enough, who can go in and figure that out.

KELLY: Did you have to do that in a lot of instances?

SHEA: I had a lot of instances of it.

KELLY: Can you think of any other examples that you think might be important or at least interesting to talk about here for purposes of history?

SHEA: I think those were the main ones. You'll find a lot of them in there [referring to documentation].

KELLY: That sounds terrific. Just for the record, for the tape, these are the Apollo Program Office weekly management reports.

SHEA: Which are in storage, as I understand, in the history office down at Houston [Johnson Space Center Scientific and Technical Information Center].

KELLY: That's terrific. Can you talk a little bit about the management reports and how you came up with the idea of communicating with all of the different offices within Johnson Space Center at the time you were developing [unclear].

SHEA: Well, it seems to me it's obvious it's mandatory. You can see the level of details, the kind of details that come out on a week-to-week basis. Unless somebody is in contact, first order, without any filter or any noise in the loop, you have to get direct information and understand where the direct information comes from. Now, it isn't that I didn't talk to these guys. If the problem looked like a big problem, then I would go talk to them. If it didn't look like a big problem, I'd just handle it by paper.

KELLY: Did you have any weekly meetings that went along with these reports?

SHEA: Yes. There was a weekly meeting that was part of the Program Office. Anybody could sit in on it. That's how we ran the overall program, the dollars, the thoughts, the schedule, that type of thing.

KELLY: Did you review the individual work packages at those meetings as well?

SHEA: No. Just whatever issues were coming up.

KELLY: How do you see that that developed into the ability to solve any problems that came up? Did you find that there were any problems with that system, or do you think that people were very comfortable with it?

SHEA: I think they were comfortable. They were more comfortable with it because they felt they were in contact with the program manager. It gave them an feeling of communication that they would not otherwise have had.

KELLY: Did you work very directly with North American, then the contractor, I think, for the command module?

SHEA: Yes.

KELLY: How about for the launch vehicle? Were you involved with the launch vehicle at all, or was that basically Huntsville [Marshall Space Flight Center, Alabama]?

SHEA: The launch vehicle was [Wernher] von Braun and his team. All they had to do was provide enough thrust to get us, with our weight, on the right velocity to orbit.

KELLY: Could you discuss the separation of responsibility between the centers? For instance, we know that Marshall [Space Flight Center, Huntsville, Alabama] had responsibility for the launch vehicle.

SHEA: Marshall had the responsibility for the launch vehicle. We had responsibility for the spacecraft and the guidance. When I first went to Houston, I took one of my better people, Aaron Cohen, who later became the center director [for Johnson Space Center]. He was the guidance guy. I said, "Aaron, where are the interface control documents?" Do you know what an interface control document [ICD] is?

KELLY: I do, but for the record, would you mind just briefly explaining?

SHEA: It's just a detailed description of the mechanical and electrical interface between various subsystems. I had learned you need that when I was in the missile program. So I said to the program office, "Where are the ICDs?" Well, there weren't any between the launch vehicle and the spacecraft and then the launch vehicle, the spacecraft, and then the ground support crew. So I said, "I want ICDs," and I gave Cohen the job of coming up with all the ICDs. It took him about a year, and he wrote about 1,100 documents.

Then later on, when I was teaching at MIT [Massachusetts Institute of Technology], he came up and gave a lecture. He was then deeply involved in the space program, and he happened to talk about this particular instance, because when I took him to set up this ICD project, I hopped on an airplane, we went down to see [Wernher] von Braun, I introduced him to

von Braun, made sure they both understood how important this was. Aaron, after telling this story, he shook his head. He said, "Gee, I wish we'd done this with the Space Station."

KELLY: That was in what year?

SHEA: It was after I retired, so it was in the nineties.

KELLY: That's very interesting. When you developed these intricate control documents, were there problems? You said it took him a year to do that. It seems like the systems were so—

SHEA: No. Once you're developing them, they really aren't a problem. You just document everything that needs to be documented.

KELLY: Were these interface control documents for the use of the folks at Kennedy Space Center [Florida]?

SHEA: As well as Johnson, as well as Huntsville.

KELLY: In fact, did these interface control documents sort of dictate where your specifications for your systems were going?

SHEA: Well, it had to be there in order for the pins to mate, for the signals to go across and mean something. It details the signals that have to go across, the range of error, and the signal that is permissible, where the physical location is going to be, the floods. So it's the whole electrical and geometrical structure that's required in order to put those things together.

KELLY: Did you find that there was any difficulty in working with the different centers and getting those documents developed?

SHEA: Oh, probably some of them dragged their feet, but we had them in a year.

KELLY: I'd like to go back and talk to you a little bit about working with the various contractors then for the guidance systems and for the command module and the lunar module, the service module, and asking you what relations were like. I think we talked a little bit last time about working with McDonnell and how folks had seen some of the different contractors for Apollo very different than their relationships with working with McDonnell during Mercury and Gemini.

SHEA: Well, there was a different relationship. The guidance system for Apollo was an independent contract with the Draper Lab, which used to be an independent part of MIT. They were initially the guidance contractor for the command service module. Then we decided there was not reason we should have any different hardware for the lunar module, so they became the guidance contractor for the lunar module, and we had it all integrated then into one piece. Grumman grumbled a little bit about that. They wanted their own guidance system. Why, I don't know. They didn't feel like they had complete control, but they managed to use the basic elements, the computer and the inertial platform and the instruments from the Apollo development, I'd say development of the whole system for the lunar module.

KELLY: Were these contracts let before or after the decision to go to the moon through the LOR [Lunar Orbit Rendezvous] mode?

SHEA: Before.

KELLY: Once the decision to go to the moon was made through LOR, how did that affect the development of both the LM [Lunar Module] and the command module or the service module, the guidance and control system?

SHEA: It only affected the equations. It didn't affect the hardware, because the hardware is a platform and then a computer, and you can program the computer many different ways. So you just change the program for the computer to be adaptable to the lunar module, because they were different equations.

KELLY: So it was a little bit different work, but it wasn't changed [unclear].

SHEA: No. It was basically the same work. It was just a different set of equations.

KELLY: How about the development of the command module or the development of the LM? That must have changed it. They thought they were going to go to the moon through direct descent or Earth orbit rendezvous. Did that change it?

SHEA: Remember, the lunar module knew it was going by lunar orbit rendezvous by definition. The thing that got changed was Apollo.

KELLY: Can you talk a little bit about that and how it affected either the contracts or the development of—

SHEA: Yes, I can. When I went to Houston, in addition to the situation I just described, the thing was sort of chaos. It was a year after the decision to go to the moon. There was no design for a

docking mechanism or anything like that, which there obviously had to be. North American had a way of making every spacecraft different, because there were like several test articles that had to be built. They didn't use one design. They would make a special design for every one. That's the most expensive way to do development.

So I got to Houston and saw that the spacecraft basically needed a major redesign, the Block I. I said, "Hey, everything is going to be the same. There's going to be one block, one type of these early Apollo spacecraft, and then we'll switch over. We'll do a Block II, and then there will be a single Block II design." That was basically the approach that I used. We had Block I, Block II for the command service module, but not for the lunar module. The lunar module was just a single block.

KELLY: May I ask you a little bit about the missions and developing the missions? Were you involved in that at all?

SHEA: Yes.

KELLY: Can you talk a little bit about how you came up with the responsibilities of each mission and how you determine the mission's success? I know that there were different missions created for Apollo. You had your "A" Mission and "B" Mission and all the way through.

SHEA: There are a number of things you want to do and get out of the way, prove to yourself that you can do it, test the hardware, and they sort of fall out of the logic of the program.

KELLY: What did you feel was most critical in reaching those steps? It seemed like it was evolution from each mission on to the next.

SHEA: Incremental testing, yes.

KELLY: Can you talk a little bit about what you felt was most critical in reaching the point where you actually decided, "Okay, let's go off to the moon"?

SHEA: Just to show that every part of the system worked in space properly. You could prove it in Earth orbit. You could have made a couple of passes around the moon. That, to me, would have been silly. Why do I do it? It's risky enough to go out there. If you go out there and it's too risky, you're just taking too many chances. So, capitalize on success, like we talked about before. If you get so far, I assume if you've made it that far, then just keep on going. It's that all-out success concept.

KELLY: I believe this was after you left Houston, when they actually decided on Apollo 8 to go to the moon, and I think they switched [unclear].

SHEA: It's a decision I never would have made.

KELLY: Right. Can you talk a little bit about that and what your feelings were at the time?

SHEA: For exactly that same reason. It was a stunt. It was Christmastime. There was the same sort of crap you just saw last week [referring to John H. Glenn, Jr. and the STS-95 mission], building up public sentiment for the program when there's no technical need to do it, all you're trying to do is public relations. That's not a good reason to run a mission.

KELLY: Can you talk a little bit about some of the reasons why you do want to do a mission, just in your personal [unclear].

SHEA: You've got to test. You're never smart enough to know everything, so you have to test to be sure that what you think you know is so. And little things can be forgotten, mixed up, so you take it all the way through, womb to tomb.

KELLY: Who were some of the folks that you worked with over in Houston? I know you mentioned Mr. Markley. Can you talk about some of the other people and your relationships with them, either on the contractor side or this [unclear].

SHEA: Markley was my main man in Houston.

KELLY: What did he do? I know he was your deputy, but can you talk about some of the things that he did?

SHEA: He did most of the nontechnical work, the clean-up work, be sure the contract was right, advice to me, and so on and so forth. He was a very, very integral part of the program. He put those books together.

KELLY: Oh, really. The management reports. He worked very hard. How about any of the others? You mentioned Dr. Cohen.

SHEA: Aaron was a good trooper. Yes, Aaron was young then, so he was still learning.

KELLY: How about any of the others?

SHEA: I'd say none that really stick out.

KELLY: If you wouldn't mind, I'd like to ask you a little bit more, again, back to the contractor side and talking about the LM development. I know that it took them many, many years to actually produce a prototype. You had called it the only Block I. Can you talk about the development and some of the problems that were encountered in its development?

SHEA: It was no different than the command module or service module would have been. There's always a certain amount of difficulty developing a particular spacecraft. There's nothing that was a show-stopper. They got heavy. They had to have their weight-reduction program. That was the biggest issue that we had. They were getting it too heavy, being too conservative in the design.

KELLY: What, in your opinion, was really driving the weight factor?

SHEA: The conservatism in the design.

KELLY: And how was that able to be resolved? Did you play a part in that resolution?

SHEA: No. Grumman did most of that for themselves. They just looked at the margins of safety and thinned things down and took weight out in a way that was safe.

KELLY: I know that they used almost like a mylar siding for the lunar module itself.

SHEA: Yes. That would be an example.

KELLY: How did that decision come about? It seems to me that that would be a really risky decision.

SHEA: Mylar was also insulation. So they had two reasons to go. There was structure underneath the mylar. The mylar was just the surface. It was mostly insulation to keep the thermal balance about equal.

KELLY: Were there any concerns at all that it might affect the mission or gravel or dust from the moon might come up and hit it?

SHEA: Oh, there's always those concerns when you're going to a surface you don't know, but, no, no major concerns.

KELLY: Did you play a part at all in some of the missions that actually went out to the moon?

SHEA: No. Once the Apollo fire came, that was the end of the program for me.

KELLY: And would you like to talk a little bit about that and how you foresaw the decisions that came about, either prior to or after?

SHEA: Well, fire was always a concern. At the acceptance test for the spacecraft, we had a discussion—[Virgil I. "Gus"] Grissom brought it up initially—about there being too much Velcro and too much other stuff around. The fire rule was that anything that might respond to a spark and start a fire should be—it was four inches in Mercury, I think, and it was like ten or eleven—ten and a half inches in Apollo. The crew liked to customize the spacecraft, and they

would put Velcro wherever they wanted. Nobody was checking on that. They had this other thing called Rocelle [phonetic] netting, where they'd put their books and so on and so forth.

And so the issue was brought up at the acceptance of the spacecraft, a long drawn-out discussion. I got a little annoyed, and I said, "Look, there's no way there's going to be a fire in that spacecraft unless there's a spark or the astronauts bring cigarettes aboard. We're not going to let them smoke." Well, I then issued orders at that meeting, "Go clean up the spacecraft. Be sure that all the fire rules are obeyed." That was in like October.

The fire was, what, January something. North American was a slow contractor. Their response to that direction which we gave them the Monday after the spacecraft was delivered, their response in that direction got to the Cape the day of the fire, and, of course, they never had time to work on it. They never worked on it. So, the fire happened. Then I got removed, for a reason that I don't understand, from the program manager position. I didn't stay with NASA very long after that.

KELLY: Can I ask you a little bit about the decision that you had made in that October meeting that you had just mentioned? To whom did you issue those orders? Were they orders directed at North American, the contractor?

SHEA: Yes.

KELLY: And did the crew at all have any interplay with—

SHEA: No.

KELLY: I understand that you were, I guess, in the midst of doing your all-up testing at that point, which really saved the Apollo Program itself, and they were doing one of the all-up tests

during the time of the fire. Would you like to talk at all about how that played a part in what happened or how it didn't play a part, to set the record straight?

SHEA: There must have been a door, probably the door that opened to the canisters that scrubbed the carbon dioxide out of the—that door had been opened many times and probably had scraped the insulation from the wire and caused a spark. I'd always said we'd find all problems on the ground. We found that problem on the ground.

It is a part of the program I am particularly bitter about because of typical North American slow response. Then I don't understand why, after everything I had done for the program, why I was only one that was removed. That's the end of the program for me.

KELLY: I believe at that point you went to headquarters.

SHEA: Oh, they found a job for me at headquarters, which I never should have taken.

KELLY: I mean, you must have been really, really distraught by that decision.

SHEA: I was annoyed, yes.

KELLY: Would you care to talk about it at all?

SHEA: No, not really.

KELLY: After that time, were you asked to testify before Congress, to talk about that?

SHEA: No.

KELLY: Did you want to at all? Did you feel like you wanted to have a say in it?

SHEA: It was as if NASA was trying to hide me from the Congress for what I might have said.

KELLY: Did you ask to make your story known?

SHEA: No, I did not.

KELLY: When you moved on to headquarters then, you obviously went back to Washington, D.C. Did you work at all with any of the programs there?

SHEA: It was a non-job. It was a make job. It had a title, but that was all. It was a non-job.

KELLY: After that time, I believe in my notes here, you worked on some of the review boards for, I believe it was the Hubble servicing mission and the station [unclear].

SHEA: Well, that was after I left NASA. Well after, years after I left NASA.

KELLY: So after you left NASA, where did you go from there?

SHEA: On to be chief engineer of Polaroid. I went to Raytheon, and stayed at Raytheon for close to twenty-five years.

KELLY: And what types of things did you work on at Raytheon, or were they some of the classified [unclear]?

SHEA: I ran divisions that ran check-out programs.

KELLY: Your expertise.

SHEA: Yes.

KELLY: Would you care to talk about any of that?

SHEA: Not really.

KELLY: Okay. I understand. I would like to ask you, however, about your involvement—I know it was well after you left NASA, but your involvement in those review boards. I believe they were in 1993 for the Hubble servicing mission, and you were involved in the Shuttle Program. Did you have any involvement in the program management as an advisor or consultant?

SHEA: No. All I did was advise whether they had done enough to make sure that the Shuttle rescue mission was safe. I did spend two sessions on that.

KELLY: What did you do in that capacity?

SHEA: Just went through what they were doing and how much work had gone on.

KELLY: So, more specifically, you reviewed whatever they were doing and what their plans were.

SHEA: That's right.

KELLY: Did you make any recommendations on your findings?

SHEA: No. By that time they had overkilled the problem, so there were no real difficulties. They were asking that it be done too many times. They were being too careful.

KELLY: After that, again like it was a really successful mission. Were you able to take part in that?

SHEA: No.

KELLY: Then you went on to the Station Redesign Committee and you were only there for a few weeks.

SHEA: That's when I got sick.

KELLY: Would you like to talk about anything that maybe I haven't brought up or haven't talked about?

SHEA: No, I don't think so, my dear…

[End of Interview]