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ALLAN R. KLUMPP
INTERVIEWED BY SANDRA JOHNSON
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JOHNSON: Today is May 9, 2018. This interview with Allan Klumpp is being conducted in Philadelphia, Pennsylvania for the NASA Headquarters Oral History Project. The interviewer is Sandra Johnson, assisted by Jennifer Ross-Nazzal. I want to thank you again for allowing us to come to your home and talk to you today.

I want to begin by talking about your background and your education, and how you first became interested in the space program. Talk about your interests early on in your education and how that led you into working at [NASA] JPL [Jet Propulsion Laboratory, Pasadena, California].

KLUMPP: I decided when I was five years old, from what my mother told me and allowed me to do, that there were two things that I was definitely going to do. One was I'm going to have one wife. And I'm going to be an engineer, because we lived right next to the flood control project in Los Angeles [California], and I could see the people working down there to construct things to avoid further major floods in Los Angeles.

We lived in a town called La Cañada. I could see what they were doing, and Lyle Robinson [phonetic], across the street from me, and I were thinking about what we could do to make our own little flood control project on our houses' land. We got my mother to actually buy us some concrete, so we did make our own little flood control channel there. That's when I decided I wanted to be an engineer, to do things that were really interesting and useful.

JOHNSON: Where did you decide to go to college?

KLUMPP: I didn't really. I didn't decide where I wanted to go to college for quite a long time after that, because we changed—my mother had no idea what she wanted to do in life. We kept moving around the country, and I changed schools 17 times before I graduated from high school.

I really lost confidence in the Oklahoma City [Oklahoma] schools because a woman took my IQ [intelligence quotient], and then she was in the back room for quite some time evaluating what it was. She came out, and she was all excited, and she said, "You just got the highest IQ we've ever measured." Which I don't think is really right, because I've known a lot of very smart people, and a lot of people who do more contributing to my ideas than I do to theirs. I didn't really believe that. I just lost confidence in the Oklahoma City schools, because if I was the smartest one there's something wrong there.

JOHNSON: You impressed them, anyway. You eventually went to MIT [Massachusetts Institute of Technology, Cambridge].

KLUMPP: Yes. I finally did eventually go to MIT.

JOHNSON: After you graduated from MIT you went to Douglas Aircraft [Company] control systems?

KLUMPP: Yes, that's right, I did. I was looking for somewhere that I could go to school where I wouldn't be drafted and could contribute, and that's why I went to Douglas Aircraft Company,

primarily because of the drafting. I had known what had happened in the Korean War and I wanted no part of wars if I could avoid it, so that was one way of doing something useful without getting drafted.

JOHNSON: It looks like you stayed there a couple years.

KLUMPP: I did, yes.

JOHNSON: Then you went to MIT for graduate work at that point?

KLUMPP: That's right, I did, yes.

JOHNSON: Did you have an idea what you wanted to do and where you wanted to go after that graduate work?

KLUMPP: I was always thinking that I wanted to go where the action was. That's why I got back into going to MIT.

JOHNSON: The action at that point was the space program. Did you feel like that was going to be where the action was?

KLUMPP: Yes, I did. So I was extremely lucky that I had gotten into that, but lucky mostly that not one of the people that I ever worked with ever caused a mission failure. I worked for 44

years in missions to the Moon, and missions to Venus, Earth, Mars, Jupiter, and Saturn, and robotic missions in the group at the Jet Propulsion Laboratory. They were all robotic missions, no human missions. Not one of the missions that I worked on failed. I can't claim credit for that, because if anybody had failed on a mission that I had been working on, it would have failed. Since nobody failed, not one of the missions I worked on failed, which is really remarkable when you consider how many missions actually did fail.

JOHNSON: Yes, that's true. Sputnik [Russian satellite] happened in 1957. Were you still at Douglas, or were you at MIT when that happened? Do you remember where you were?

KLUMPP: I think I was back at MIT.

JOHNSON: Do you remember the reaction at that time at MIT? You said you wanted to go where the action was. Do you remember thinking "That's it, that's what I want to do"?

KLUMPP: Yes, I remember that I had to have a secret clearance. I did work for a laboratory where they were doing some military work, even at MIT. That's when I found out, when I had to have secret clearance, that my name on the birth certificate was different than what my mother had told me my name was, so I had to straighten that out.

JOHNSON: That's interesting. Right around that time of Sputnik, you were at MIT, and then you went to JPL, to the analytical design group, in 1959.

KLUMPP: That's right, I did. That's right.

JOHNSON: What made you decide to take a job at JPL?

KLUMPP: Because Dick Morris [phonetic] from JPL had interviewed me and offered me a job, which looked like a very good job, and did not involve making weapon systems. I did not want to contribute to weapon systems, considering what had happened during Vietnam [War]. During Vietnam the newspapers were full of headlines which said that there were 30,000 Vietcong killed yesterday in Vietnam. How did they know? These were killed mostly—the strafing from airplanes. I decided right then and there that I was never going to contribute to a weapon system program. I knew darn good and well that they had no idea how many of the 30,000 were Vietcong and how many were on the other side. Civilians on the other side. But they just quoted these wildly incorrect data as if it was all true, and I knew damn well it wasn't true at all. I decided at that time I was never going to contribute to another weapon system program.

JOHNSON: It was a good decision. Talk about when you first went to JPL. Do you remember some of the projects you were working on?

KLUMPP: I was working on the project [Mariner 2] for flying past Venus and taking pictures of Venus by the spacecraft that went by them, and I designed the control system for scanning Venus when it went by. It turned out that that scan did get pictures of Venus, so that worked.

JOHNSON: Were you working on the Ranger Program also?

KLUMPP: Yes, I was.

JOHNSON: That was really the first unmanned spacecraft ever sent to photograph the Moon. At that time period that was quite an accomplishment. They were sending images back to Earth from that. Do you remember seeing images? What did you think when you saw those images?

KLUMPP: I don't really remember, but you should know that there was an earlier mission to land a spacecraft on [the Moon]. It was called the Surveyor spacecraft. It actually landed on the Moon, with a soft landing. The reason for that program was to make sure that the dust from the Moon did not just all blow away from the engine, and that the spacecraft could land successfully. Because if it couldn't land successfully, you couldn't have landed the Apollo missions on the Moon. Everything did work right with that mission. I contributed a little bit to that mission, but not very much.

JOHNSON: In 1960 you actually went to [NASA] Langley [Research Center, Hampton, Virginia] and worked with Don [Donald C.] Cheatham and Bob [Robert G.] Chilton in the Space Task Group.

KLUMPP: I sure do remember that.

JOHNSON: The proposal evaluation team. Can you talk about that team and what you were looking at at that time?

KLUMPP: I was reading the industry proposals for what was going to happen in missions to the Moon. There were something like 50 different industry proposals, something like that. There were many dozens of ones that we examined and evaluated as to how good they were. But it was mostly Chilton and Cheatham who did the evaluation, and the rest of us just summarized what we got out of the proposals.

JOHNSON: How did you get picked to go on that team?

KLUMPP: Because the person who'd hired me at JPL, he was asked to go. He didn't want to interrupt his family life and go there, and I agreed to do that for a short time because I thought it was where the action was.

JOHNSON: Do you remember some of the proposals? What was the process? Did they just come in and give their proposal over a period of time?

KLUMPP: No, they were all written, and we just had to read the proposals and evaluate them. I don't remember that the evaluation was too useful, but it was mostly just summarizing what was in the proposals. That's what we really did.

JOHNSON: Was NASA thinking of using industry more than what they ended up using them as partners? At that point were they just looking for ideas from everywhere, just to figure out what they were going to do?

KLUMPP: Yes, I think the latter. They were really just looking for ideas from anywhere about what could be done.

JOHNSON: That was in 1960. But the President [John F. "Jack" Kennedy] announced in May of '61 that he wanted Congress to divert funds to get a man on the Moon by the end of the decade. That was quite an amazing announcement.

KLUMPP: It was.

JOHNSON: I know a lot of people, it took them by surprise that that was going to happen. What were your thoughts?

KLUMPP: It was amazing that we had made a commitment to do that. Right after that happened, I was asked to serve as part of the [Systems Support] Group at NASA Headquarters [Washington, DC]. The JPL had a team there that was doing that work there, and I became part of that team.

I was very interested in, primarily concerned about, the reliability of flying to the Moon and back. I did an analysis when I was at NASA Headquarters, based on the known reliability of the ballistic missile program, to compute—there were three different ways of going to the Moon.

There was direct flight to the Moon, which was the most expensive, but the safest. There was an intermediate mission, which was never really considered very long, which was Earth-orbit rendezvous. Then there was lunar orbit rendezvous, which was easily the most dangerous.

The ballistic missile analysis that I did, based on our ballistic missile reliability, was if we choose the lunar orbit rendezvous, there was only a 10 percent chance of any mission getting all the way to the surface of the Moon and back to Earth, considering how many operations had to be done at the Moon.

It was just an enormous difference. There was about 1 chance in 10 based on the calculations that any one mission would get there to the Moon and all the way back to the Earth. But that was the cheapest way to do it, and NASA settled for the cheapest, even though I voted against it.

JOHNSON: Did anyone else vote with you?

KLUMPP: I don't remember whether anybody else did or not, but that was what was chosen.

JOHNSON: Do you remember how many people were on that team? Or about how many different people? Was it a large group?

KLUMPP: About 10 or 12 of us who were working on that.

JOHNSON: Joe [Joseph F.] Shea, was leading it?

KLUMPP: Yes, Joe Shea was very prominent in that.

JOHNSON: I was reading in one of the books—I don't know if you remember this instance, but at Headquarters you saw a presentation. There were two slide projectors at once, and you were talking about how impressed you were at the technology at that point.

KLUMPP: I was impressed primarily by how little it was possible—the percentage of what you could remember by having two people with two projectors at once, and you're listening to two people talk at once. You have to look at two different screens and follow two different lines of thought at once, and that was impossible.

JOHNSON: Maybe not the best way to get their point across. That's interesting just because the way technology has changed. When you go back and look at that time period, when you were deciding something really important, and it had people's lives in the balance. Like you said, it was the least safe as far as you were concerned.

KLUMPP: It was the least safe, yes, it was the least safe.

JOHNSON: As a group, did everyone feel that you could get past that? You said there was a 10 percent chance that it would be safe.

KLUMPP: For any one mission there was only a 10 percent chance that you'd get all the way to the surface of the Moon and back to Earth, on any one mission.

JOHNSON: But they felt that that was okay? That percentage was worth trying?

KLUMPP: They thought that they could improve the safety of it.

JOHNSON: They were confident that that could be improved.

KLUMPP: Yes. It turned out that that was correct. I think that the big thing that happened during the interim was that digital computers got to be far more reliable and far more capable than they were at the time that I did those calculations. I think the digital computer industry came through with big margins.

In fact, the first computer we had doing all of our work for us at the MIT Instrumentation Laboratory, commonly known as MIT/IL, was a Honeywell [Inc. H-]1800 computer. My wife and I lived next door to a person who worked for Honeywell. I had put in, in my simulation for the descent guidance checking, on the correctness of the things that were computed by the Honeywell 1800 computer. They were getting wrong answers all the time. Any time that you saw lightning out the window of the lab [laboratory], this Honeywell 1800 computer was likely to stop. With my simulations at least, because I was checking the correctness of their data, it was failing tests all the time.

But the person that lived next to us worked for Honeywell, and I asked him, "What about the safety of your computers, the reliability of your computers? They're making mistakes all the time."

He said, "Tell me about it. Honeywell is in the process of paying off a farmer who raises hundreds of chickens in the Midwest, because they were using our computer to compute the optimum diet for the chickens and he wound up with 5,000 dwarf chickens." So the Honeywell

was soon moved off and replaced by an IBM 360 [Model] 75 which was self-checking, and that was the end of my program finding errors. Never again did my program stop.

JOHNSON: You mentioned you went back to the Instrumentation Lab at MIT in 1963. What made you decide to go back there when you were working for NASA before that?

KLUMPP: Primarily I liked the challenge of being involved in a manned program.

JOHNSON: Had it already been decided that they would be working on the software at that point?

KLUMPP: Yes, it had been decided. That's why I went back there. I never returned from NASA Headquarters to JPL, I just applied to the MIT Instrumentation Laboratory and was hired there.

JOHNSON: Let's talk about some of those early days and couple years at Instrumentation Lab.

KLUMPP: Yes, and I'm prepared to. I had already concluded that one of the things I wanted to talk about was women's role in that, because we had something like 300 engineers, all men, who were doing all the work on that. I thought that that was not right. Then somehow a woman named Margaret [H.] Hamilton was hired. She was brilliant, and within a year she was my boss's boss, Margaret Hamilton. If you go to Central Square, Cambridge today and just look at the organizations that are situated in Central Square today you'll find that there's a Hamilton [Technologies, Inc.] computer engineering company there.

JOHNSON: And that's her.

KLUMPP: And that's her. The only fault I find with that is that she's done the reverse. All the people that work there are women.

JOHNSON: Kind of giving a leg up to the female side?

KLUMPP: Yes. Meanwhile, even though when I graduated from MIT they had only 50 women at MIT, now it's about half-and-half. I think that women have advanced properly.

JOHNSON: Yes, at least there's a lot more now than there used to be. That's very true.

KLUMPP: I think that in most colleges there is about half-and-half nowadays, and that's the way it should be.

JOHNSON: When Margaret Hamilton came to the Instrumentation Lab, what was the reaction of people you worked with? Were there men that said, "No, I don't want to work with a woman"?

KLUMPP: I don't remember that there were. In general, people were trying to be fair about things at the MIT Instrumentation Laboratory. Not only about the relationship there, but also about the difference between Christian and Jewish religions. The holiday season was called the yule season, so it wasn't either Christian or Jewish.

JOHNSON: Yes, it was very forward thinking at the time, wasn't it?

KLUMPP: I think it was, yes. I like that way of thinking.

JOHNSON: Seems like it was a good place to work at that point in time.

KLUMPP: It was, yes. There wasn't any doubt about it.

JOHNSON: When you were there at the beginning, I was reading that you worked on a pen-and-ink drawing of the simulations of what the views of the lunar surface would look like outside of the LM [lunar module] cockpit for the astronauts to train.

KLUMPP: That's right, I did. That's what I was assigned to do actually. I allowed the people who used the simulator to specify what craters were on the Moon in the vicinity of the landing spot and what they looked like. I would draw pictures of what the craters would look like as you came down into a proposed landing site, where you could specify. I actually made a movie of it. It was very coarse in time, where I every two seconds during the descent drew a picture of what the craters would look like at that point. That was a pretty crude movie, but it seemed to catch the attention of an awful lot of people.

JOHNSON: Did that allow you to be assigned to other projects because of that?

KLUMPP: That was just part of what I was doing on the lunar descent. You might be interested in Don [Donald] Eyles. You've heard of Don Eyles and his book [*Sunburst and Luminary: An Apollo Memoir*].

JOHNSON: Right. I was reading some excerpts from things that he had written, too.

KLUMPP: That is an excellent book. I'm still in the process of reading it actually because I've still been working on this project, but it's an excellent book. But Don Eyles, you might want to know—are you interested in things that are primarily amusing?

JOHNSON: We always like good stories, yes.

KLUMPP: Don Eyles at one point—he was a member of my team. So he was translating everything that I did in a higher order language. He was translating that to the language of the Apollo guidance computer. At one point he and I had a difference of opinion about something that I thought should be in his translation that wasn't there.

I asked him to put it there, and we had a back-and-forth argument about it. He didn't want to put it there, but eventually he did. But he put it in a box. The box surrounded the new code and had an explanation at the top of the box, "The code in this box was added at the demand of a Byzantine dodo bird."

In later years, he forgot he ever had that in there. It disappeared after not very long. It was there for a short time, but there was a Byzantine dodo bird in that box, referring to me. Byzantine means in the 15th century.

JOHNSON: He was pretty young when he was recruited, from what I read.

KLUMPP: Yes, he was. He was very sure of himself. I'm sure you should be interested in what actually happened when he first started out. We had a simulator that was already being used by about 300 different people. He looked and started reading the code in the simulator and he noticed that there was a mistake in one place. The simulator was run by just boxes of [punch] cards. There's about 2,000 cards in a box this long [demonstrates], and several boxes of cards involved in the total simulator, which had been developed by hundreds of people.

He found this error, and he was so sure of himself—because he was a member of the Mensa society and still is, which is a group of people whose intelligence is way above average. He was so sure of himself that when he found the errors, he was sure that he could easily fix that in no time, and he threw away the cards. So the cards were lost. The first attempt to fix it didn't work, the second attempt to fix it didn't work.

It took him a week to get it going, and finally George [W.] Cherry, who was his supervisor—he was also the person that had assigned me to work on the Apollo Lunar-Descent Guidance—came to me and asked me, "We've lost 300 man-weeks of time because of Don Eyles's screwup." He said, "I think we should fire him."

I said, "I don't think so. He works so well, he'll make it up." George finally decided not to fire him.

JOHNSON: Did he finish it?

KLUMPP: Yes, he sure did, yes. Not only that, eventually in Apollo 14, when the abort switch failed, Don Eyles figured out a procedure that the astronauts could follow so that the failure of the abort switch—which was failing over and over and over again—would not prevent them from landing. That saved Apollo 14.

So Don Eyles did the work that caused Mayor Kevin [H.] White of Boston [Massachusetts] to award an honorary prize to the entire lab. He specified that anybody that was on the lab at the time that that was done would share in that award of good work. He wasn't just singling out Don Eyles for doing it.

I happened to have arrived at the lab quite a bit early the day of the Apollo 14. The descent wasn't normally going to be started until something like 10:00 p.m., and since I had arrived at the lab at about 5:00 in the morning to do other things and make sure of something else that I didn't think would be a problem—and it turned out it wasn't a problem, I actually figured that out during that day.

But by the time around 9:00 that night, I was getting pretty tired. So I went to the only place that you could actually lie down and get some sleep about 7:00 p.m. or something that day, after having been there for 14 hours. I went to sleep in the hallway that led to the ladies' room. When I was finally awakened and told what had happened, Don Eyles had already fixed it, and the landing had already taken place.

So I got an award from Mayor Kevin White for being asleep in the ladies' room.

JOHNSON: For taking a nap. That's pretty funny. If he hadn't figured that out, they wouldn't have been able to actually land.

KLUMPP: They wouldn't have been able to land, because the switch—the communication went like this. "Houston, the abort switch is on again." "Well, turn it off." After that happened for quite a few times, it became clear that it was failing. It took 17 minutes to go down. It was failing once every minute or two, so the probability of landing was very close to zero. If he hadn't figured out a procedure that they could follow—so Don Eyles actually saved Apollo 14. But I claim I saved Apollo 14 indirectly by having Don Eyles still there.

JOHNSON: That's right, you kept him from being fired, so you deserve that award too. I was reading that what he did would normally take a week or so to figure out, and he did it in such a short period of time.

KLUMPP: He had the mental strength to do something that very few people did.

JOHNSON: It's pretty impressive.

KLUMPP: Yes, it was. No doubt about it.

JOHNSON: Talk about when you were with the Instrumentation Lab and you were working on that descent guidance and the LM steering systems. At NASA, at Johnson [Space Center, JSC], there was the Mission Planning and Analysis Division.

KLUMPP: MPAD, yes.

JOHNSON: MPAD, they were working on that. Talk about the relationship between MPAD and the IL where you were, and how that relationship worked. Did you work with anyone at JSC or at NASA at that time?

KLUMPP: I did, yes, I worked with Jim [James H.] Alphin primarily at JSC. I also worked with other people at JSC too, one of whom had come up with a scheme for the descent guidance which would improve the performance in terms of how much fuel it would take to do the landings. One of the JSC people did come up with an improvement to that and I supported him on the improvement.

But the person who had to make the decision on it, Bill [Howard Wilson] Tindall [Jr.]. You've probably heard of him. He's not living anymore, I understand. But he decided against the improvements that the JSC fellow had made, because it didn't make enough difference. It reduced the fuel consumption but not by enough to really matter, and Tindall decided that it wasn't worth changing everything around for such a small improvement.

I must say I think that Tindall was the best manager I ever worked with. He was just absolutely right on everything that he decided should go. I thought he was even right on turning down that reworking the descent guidance to the extent that would be necessary if you actually adopted that improvement. There was no doubt it was an improvement, but not enough to be worth the cost of overthrowing everything that was there already in order to make such a small improvement.

I thought that Bill Tindall was the best manager I ever had worked with. There wasn't one thing I ever saw him decide that I didn't think was right.

JOHNSON: We've heard from a lot of people about him. That he was able to listen in a meeting to everybody's information and ideas, and then take that information and condense it down into the right decision.

KLUMPP: Exactly. Yes, that is true. I think that he deserves to be remembered for the quality of his management, which was absolutely superb.

JOHNSON: I know he was famous at JSC for his "Tindallgrams" [memoranda].

KLUMPP: Exactly.

JOHNSON: Did you get those, too?

KLUMPP: They're still being circulated actually. They're still being circulated. People that go to the luncheons, those of us who did so much work on Apollo, are still speaking about Tindallgrams decades later.

JOHNSON: It's an amazing legacy.

KLUMPP: Yes, it is. It's an amazing legacy just to have worked with so many people, not one of whom ever failed to the point that we lost any missions.

JOHNSON: I was reading, and it was attributed to you, that you said, about Apollo, that the task was a daunting one because there was no possibility you could ever try again. I thought that was interesting. When you first started working on this, you were very aware that it had to work. The software had to work. Sometimes when we talk to people they're so focused on what they're doing, the technical part of it, the realization of what they were really working on and what it meant to the entire nation—they didn't really see that until after it was over. But it sounds like you were aware that it was extremely important when you were working on it. Did you have any idea about the way the world would react once you helped accomplish that?

KLUMPP: I didn't have any idea about how it would react, but I got a definite impression about the difference between our program and the Russians' program. Because several months before the landing in 1969, there was a worldwide meeting in Vienna, Austria, in which the Russians and the U.S. were each going to describe all the things that we worked out. We had no restriction. We could tell the Russians anything at that point, so we were given full authority to tell them everything.

There were Russians there, and my talk to them on the descent guidance came before their response to it. The Russians were in the audience, and asking me every once in a while questions about "How does this work?" And I explained to them, and they seemed to understand everything.

Then when it came to their turn, I started asking them the same kinds of questions about the same things. "Well, how does yours work on this?" They always said, "I can't understand the question." Even though they could understand my answers, they couldn't understand my questions using the same words.

JOHNSON: They weren't going to share their information as freely.

KLUMPP: They weren't going to share their information at all.

JOHNSON: That's interesting that you got to go to that meeting though.

KLUMPP: I thought it was, too. But years later there was another meeting between the various nations in Dubrovnik, Yugoslavia [now Croatia], which is right on the coast. It was going to be another meeting where the Russians and we were going to interchange our ideas. But the Russians were not intermixing, even though there were people from Germany and so forth. They were not intermixing with any of the rest of us. They went everywhere on their own bus.

Then finally, at the end of that meeting in Dubrovnik, there was a time we were going to have a picnic on an island that was off the coast by five miles or something. We were all going to be together on the motorboat that was going to take us all out to that island so we could enjoy one another socially.

Nobody had seen any of the Russians before we all got on that boat together. I asked one of the Russians, "Why is it that you're not intermixing with the rest of us much, but you're going only on your own bus all the time?"

The guy who I asked that question said, "Well, when we came here to Dubrovnik they gave us only chewing gum money, and if we pooled all of our money it would not be enough to buy an aircraft ticket anywhere else." So we got the picture that they were still being unduly controlled by their government. You may remember [Mikhail S.] Gorbachev from Russia, who

was the most humane of the Russian leaders, I thought. In fact, he became so well known in the United States that people said that if he were to run for president here, he'd probably win.

JOHNSON: In those early days of Apollo, one of the things you worked on was programming flights on a simulator, because the crew wanted to land themselves. They were wanting to do things more manually. You programmed manual flights into the simulator, and every time you did that with the crew controlling it they crashed. So you knew at that time that the landing was going to have to be a combination of that crew ability, or what they wanted to do, but you had to have that computer support.

KLUMPP: I had programmed that the crew could specify where they were landing by manipulating a stick, like the joystick on an airplane. Each time you moved the stick forward or aft it would respecify where the landing site was, either forward or aft, according to the direction you moved it. Or left and right, it would do the same thing left and right. That was very soon adopted as being the way that it was going to work.

The only thing that I did differently than the way that it actually did work in flight was that I had it so that it would move the landing site, where it was located, left or right by about the same amount in terms of the length. The astronauts decided that they would rather have it move by the same angle, whether it was forward or aft or whatever. So that's what actually flew.

JOHNSON: Was that the landing point designator?

KLUMPP: LPD, yes, that's right. That's the way that worked. That was my idea. Except for changing the constants involved, it worked the way that it was supposed to.

JOHNSON: That gave the commander, as they were landing, the ability to manually make those last-minute changes in case the computer had designated a place that wasn't necessarily a good place to land.

KLUMPP: Yes, for instance on a pile of rocks or something like that. You could always change where the landing site was by moving this control stick. It turned out that I wasn't the only one who thought of that. There was another person who did think of that some years earlier. Phil [Philip G.] Felleman had thought of that earlier. I don't know whether you know of Phil Felleman or not. He's no longer here, he died quite a few years ago. But he said, "We had that running years ago." I have no way of verifying or denying it, so I will just allow that to stand.

JOHNSON: That was a little different though. With other spaceflight that came before Apollo, they didn't give that much control to the astronauts. So this was a little different. It was a hybrid between allowing the computer to do it, and then letting them control what they were going to do.

KLUMPP: That's right.

JOHNSON: It definitely came in handy on Apollo 11.

KLUMPP: Yes.

JOHNSON: Talk about some of the work leading up to Apollo 11. You mentioned sleeping on the couch during Apollo 14, but also working up until that first landing you were spending a lot of hours at the lab. What were your days like? How often did you get to come home?

KLUMPP: The days were long days. You know of another book by Hugh Blair-Smith [*Left Brains for the Right Stuff: Computers, Space, and History*]. Have you seen that book? Don Eyles wrote a book, but Hugh Blair-Smith also wrote a book.

Hugh Blair-Smith was the most amazing help, and he was just helpful to everybody. How he managed to do it is just beyond me, because I was working in batches of software. I'd collect a whole lot of different thoughts, and gradually work out the thoughts. Before, it was necessary—with the way in which our computer system worked—to have spreadsheets with all of the work showing on the sheets. That's what the computer actually operated with in the early days. There was no visual thing at all, it was all just on paper.

We'd work on a large amount of software which would involve several sheets of paper being changed, and submit the entire paper, and that's what would fly on the simulator. The next day we would get results back, sometime the next day. Because if you were working there till 9:00 or 10:00 p.m., or 11:00 or midnight—and I actually worked many days until midnight. In fact, when it came to putting that in, I oftentimes came to work one morning and didn't come home until the next night. So it was a 36-hour, 40-hour day. The computers didn't work so fast that you could immediately tell what was going on with your run.

Hugh Blair-Smith, when I submitted my output to the computer, was oftentimes still there. Since he designed the computer language, he knew how to read those sheets. The next morning when I would come to work—and this happened dozens of times—I'd find his output on my desk the following morning with a note saying, "You made a mistake at this point and I corrected it and here's the corrected output." He was there much longer than I was.

JOHNSON: That's pretty amazing.

KLUMPP: It is. The number of times that happened was dozens.

JOHNSON: Really. I guess it was good that he was finding the mistakes, that's for sure. I imagine working long hours made it hard sometimes not to make mistakes.

KLUMPP: Yes, that's true. In one particular case I took a taxi home at midnight, and the financial people at Draper Lab decided that they weren't going to pay for taxis home, even though it was at midnight that I took a taxi home. The managers who had final responsibility even over the financial people said, "You will pay for the taxi." So they did pay, but they had originally supplied me with a notice that they weren't going to pay for taxis home at midnight, and they were overridden.

JOHNSON: That's good, because I imagine you were a little too tired to drive at that point. Think they'd rather have you back safely the next day than worry about that.

In 1967, I was reading that you were about midway into developing the guidance and navigation hardware and software. Your group received an unusual directive from NASA, and that was to make no attempt to avoid gimbal lock. It was a problem that you were worried about in the simulations, but they told you basically not to worry about it, and not to attempt to fix that, and to move forward. But I believe actually after you did what you were told, you went back and figured out how to fix it anyway.

KLUMPP: I did. I had figured out a way to fix it. That was after Apollo 12 had flown. NASA decided that they weren't going to use it for Apollo 13, because it hadn't been sufficiently tested, since it had only been fixed shortly after Apollo 12 flew. They decided not to adopt it.

But the commander of Apollo 13 [James A. Lovell, Jr.]—I knew him pretty well, and I knew he was training at the Cape [Canaveral, Florida]. I called him one morning about 6:30 in the morning. I knew he got up awful early to be training. I called him at 6:30 in the morning, and I told him about what the differences would be depending upon whether it was flown or not.

I didn't hear what was going to happen during the telephone conversation because it was his bosses who had decided not to do that, not him really. But the morning that I called him at 6:30 in the morning, we had about a half-an-hour conversation. About 10:00 a.m. that day my boss came into my office and said to me, "Your political *savoir faire* has reached a new low," because he had heard what had happened.

Jim Lovell was able to persuade NASA to use the new program, and that's what flew on Apollo 13. The new program did fly on Apollo 13.

JOHNSON: Why don't we go ahead and talk about working up to Apollo 11? I was reading that part of what you did, there was a Guidance Systems Operations Plan, GSOP. Part of what you took part in was crew training. Were you training the astronauts on the guidance systems operations plan so that they would be familiar with it during the flight?

KLUMPP: Yes. It was really amazing how that crew training went off, because the commander of Apollo 12 was by far the most capable of the commanders.

JOHNSON: Pete [Charles] Conrad [Jr.]?

KLUMPP: Pete Conrad, yes. He was absolutely amazing. He asked all of us who had written anything about what we had been doing—he asked to get copies of anything we had written, and he was absolutely unbelievable in terms of what he could understand.

When we were doing the crew training—supposedly we were doing the crew training. When we were talking about various technical details, often after we had described one of the details of it, he would speak up and say, "Don't you mean such and such?" and describe it. No matter who he was talking to, the answer was always, "You're right, Pete, that's the way it should be described." He was amazing in his ability to understand things and make corrections if necessary. The rate at which he thought, the way that he got the answers right so fast that you just couldn't believe that he could think that fast.

After Apollo 12 had flown to the Moon and back I happened to be at Houston for something else. I forget what it was, but I was in one of the hangars in Houston and he walks in. Just being around somebody who had actually walked on the Moon was exciting to me. I said,

"Pete, you're not going to tell me you've actually walked on the Moon, are you?" His answer was, "No, it was a trick we did with mirrors." Repeating what the public had been led by some people to believe, that there had never been an Apollo mission to the Moon.

JOHNSON: He did have a good sense of humor from what we hear.

KLUMPP: He did. He was a real joy to work with, at the level of Bill Tindall. Bill Tindall and Pete Conrad were two of a kind in terms of their intelligence and their ability to knock down the right answer that fast.

JOHNSON: When you were doing that training, was that in Houston? The crew training on the GSOP?

KLUMPP: It took place in various places, I think both at the MIT Instrumentation Laboratory and in Houston. But it hardly mattered where it took place, because as far as Conrad was concerned he was always on top of it.

JOHNSON: Were all the Apollo astronauts trained at the same time or was it by crew?

KLUMPP: There were groups of astronauts. I don't know whether it was all of them at the same time, but nobody ignored what Tindall or Conrad said.

JOHNSON: Talk about for a minute that GSOP. That was a documentation of the software for the systems that they would be working with. It was large, from what I read. It was pretty wieldy and large. Documentation though is important. Can you talk about the need for accurate documentation?

Plus you were very specialized in what you did. You were a computer programmer, software developer, engineer, and you were talking to pilots. Very smart pilots obviously, very intelligent and capable. But you were also teaching them things that wasn't their specialty. Maybe talk about teaching them those programs and things that they would have to understand?

KLUMPP: What happened with two of the candidates for becoming astronauts was that they asked me, and probably other people, to send them copies of what we had written. I did, and I suspect they probably got them from other people, too. Both of them have walked on the Moon now. They both made it.

JOHNSON: That was quite an experience, getting to teach them the things that they would need to know to do that. Let's talk about some of the programs that you were writing during that time. I noticed some of the names were interesting. The one on Apollo 5, I was reading the program's name was SUNBURST, and then Apollo 9 it was SUNDANCE. And then Apollo 11, I think by that time the program had evolved and it became LUMINARY. Those were some of the program names, which I thought was interesting. Where did the names come from, do you remember?

KLUMPP: I don't know. I do know what the version numbers were. LUMINARY 130 flew on Apollo 12, and was about to be repeated on Apollo 13 when I got authorization to release the one that corrected the errors from Apollo 11. So that was 131. If you want to think of it in terms of the number 13—which stupidly is considered to be a bad luck number—that's 13 going and coming, and so LUMINARY 131 did fly on Apollo 13.

JOHNSON: As we know even today, computer programs are constantly being improved. As you were working through all these, all the way up to Apollo 11 these programs were being changed, evaluated, simulated, and everything was moving forward for Apollo 11.

KLUMPP: That's true.

JOHNSON: So you had different revisions even as you went through the program itself. On Apollo 11, let's talk about the launch. You got to go see the launch, is that correct?

KLUMPP: That is correct, yes. Anybody who had made a major contribution, NASA invited them to go to Florida to watch the liftoff of Apollo 11. That included my wife and me. None of our children did, but Sue and I both did.

JOHNSON: That's quite a perk for all the hours you put in though.

KLUMPP: Yes. I did put in quite a bit few more hours than I was paid for, but to be able to participate in something as important as that was well worth it.

JOHNSON: Can you talk about that experience of seeing the launch and how you felt seeing it?

KLUMPP: We were in like the grandstand surrounding a football field, and we could all see and hear the launch take place. Seeing that was very exciting, and hearing it—it was making such an enormous amount of noise that it was practically ear-shattering to watch Apollo 11 take off for the Moon. That was really quite an experience. It was just like the bleachers of a football field. There must have been 100,000 people there or something.

JOHNSON: The roadways, everybody was just pulled over and camping. The photos are amazing, when you look at the photos of the roads and everything around there. Quite an accomplishment.

KLUMPP: I think that we got there using an Avis rental car. It landed in Orlando, Florida, and we drove there. But I had already established a reputation at Avis, because several times actually earlier I had stopped at Orlando on my way to something that was going on at NASA. The first time I used Avis was an interesting experience, because the Avis rental car people never forgot me after that first trip that I used one of their cars.

The reason why was that when I first got in the car and I had driven a few miles down the road, I noticed that the water temperature had gone up and it shouldn't have gone up. I figured that the radiator must have been not filled. They must have given me a car that didn't have the radiator full, and that's the reason why it was going up. I had just come down from Boston, and

I had in my bladder enough to finish filling the radiator, I thought. So I finished filling the radiator, parked next to the road.

JOHNSON: That's one way to do it.

KLUMPP: That didn't quite fill the radiator, but then there was a crew that was working next to the road, right next to a stream. I parked there and got them to give me some muddy water. I filled it the rest of the way with the muddy water from the radiator. After that, every time when I rented an Avis car, they said, "Oh, you're the guy who—"

JOHNSON: That's quite a reputation to have.

One of the things your daughter mentioned, one of the stories you told them, was that there was some kind of a mix-up at one point. I don't know when this took place, between measurements taken in metric versus imperial. Was that with Apollo or was that later on?

KLUMPP: No, that was an unmanned mission to Mars [Mars Climate Orbiter]. I do remember quite well what happened, although I didn't actually witness it. I remember it quickly made the rounds at JPL that there were a couple of guys that had a fistfight. Each one saying, "You caused this. You made this mistake and that mission crashed." "No, you made it." They actually had a fistfight I'm told. I didn't watch it, but I have no reason to disbelieve it.

But it turned out that neither of them did. That wasn't a mission that I worked on, because not one of the missions I worked on ever failed. I hadn't worked on that mission, but it turned out that I did share in the knowledge of what actually did happen. It was that in Colorado

there was an aerospace company that JPL had hired to process the data that would relate how the attitude control—that's the orientation in space—was affecting the trajectory of the rocket that was coasting from Earth to Mars. The data turned out to be wrong, and instead of entering at the right place at Mars, because the data was wrong it entered at the wrong place and the mission was lost. That's what happened on that mission.

What had happened was that the specification about the data that they gave us back from their analysis had to be in the metric system of units, and they didn't pay any attention to that. Who knows why? Your guess is as good as mine. Nobody I think knows why they didn't do that. But it was in the English system of units, and that makes it very wrong, and so that mission crashed. But fortunately I never had that happen on any mission that I worked on, and that's just good luck. That's all you can assign it to. I was just very lucky that never happened.

JOHNSON: Let's go back to Apollo 11 then. Talk about when the LM actually landed on the Moon and that time, and some of the alarms that were going off. You and Don Eyles had been working for three years at that point to produce those programs to get that LM on the Moon.

KLUMPP: I know exactly what happened.

JOHNSON: Let's talk about that, and if you don't mind, where you were, and how you were listening to the landing. Was that something that you heard real-time as it was happening?

KLUMPP: Yes, it was. I happened to be in the room in Cambridge, Massachusetts, where it was being broadcast. We kept hearing, "Another alarm." What had happened was—and I learned that shortly thereafter, exactly what did happen.

There was a fellow named Russ [Russell A.] Larson. Long before that I had shared an office with Russ Larson for a short period of time. He told me what happened at the 25th anniversary of Apollo 11. He told me that what had happened was that the commander of Apollo 11 and/or the person who was going to be the copilot—

JOHNSON: On Apollo 11, it was Neil [A.] Armstrong and Buzz Aldrin.

KLUMPP: Armstrong and Aldrin, yes. One or the other had told him that. Russ Larson had been asked to make up the crew checklist, and one of them called him on the phone and said that we should start the abort guidance to run by turning on the switch for that before we actually begin the descent. Because if you do that and we have to abort, we don't lose time getting the computer to change what it's doing and return to where the command and service module—where in orbit we could reduce the time to rendezvous with the other vehicle. That would make an abort safer. So Russ Larson said that since he was being asked that by the astronauts, he just added that to the crew checklist to turn on the abort guidance well in advance.

But then when it actually went to landing what had happened was that—the facts are that turning on the abort guidance, and running that along with the descent guidance at the same time, increased the load on the computer by 15 percent and there was only an 8 percent margin. There was only an 8 percent margin, but it increased the load on the computer by 15 percent. That's

the reason why there was all that series of alarms that came primarily during the most busy phase, which was as you approached the landing site.

So that was causing a whole series of 1202 or whatever the number was. Those alarms were all being generated because of what Russ Larson did. That's what he told me 25 years after it had happened, so I didn't even know till that time.

JOHNSON: I believe he also told you that he was afraid to talk?

KLUMPP: Yes. When he told me that, he said that what happened, what he did during that landing, was that he was there watching. It was set up so that you could watch on a single screen the actual trajectory and the one that had been programmed. He was watching that on the screen.

I knew that Russ never knew—he didn't know the difference between those. He didn't understand how those landings worked well enough to know that it didn't take very much. You could hardly even see the difference on a plot, between an actual trajectory and a trajectory that was going to go down under the surface and come back out after having—because simulators don't know about the consequences of having a negative altitude above the surface.

So he was watching that, and he thought that it looked like they were pretty close together. But I knew, had known for years, that they can look like it's very close together—but you can fly under the surface and back out and get to the right place in the simulator, which isn't affected by going under and back out of the surface. So I knew that he didn't understand enough to have been doing that anyway.

But he said that he eventually was called from where the people were actually controlling things at Houston, "Are we go or are we abort?"

"I just gave them," he said, "a thumbs-up signal."

I said, "Well, why didn't you just tell them, 'We're go'?"

He said, "I was too scared to speak."

JOHNSON: Things did work out, but I imagine during the time when you were listening to it as they're trying to land and those alarms were going off—I imagine that was pretty frightening.

KLUMPP: It was most frightening because the slight changes of the trajectory were using more fuel than what people counted on. When they finally touched down they had only 30 seconds left of fuel in the tanks for a roughly 17-minute descent. Thirty seconds left. Nobody likes to drive a car that close. He finally did do the final descent himself.

JOHNSON: I know it was pretty frightening for the people in Mission Control, so I imagine listening to it where you were at MIT it was pretty frightening there, too.

One of the things I read in one of the articles that Don Eyles had written, that it really bothered him—because after the landing, everything was okay, but the media was portraying it as a computer error. It really bothered him that that was happening because it wasn't a computer error, as you explained. Do you remember that, or being bothered by that, too?

KLUMPP: I never was bothered by obviously wrong reports. So I was not bothered by that.

JOHNSON: Because you knew—well, you found out eventually—the true reason. But you went for 25 years without really knowing what the actual cause was. What did you think during that

time before you talked to Russ Larson, in that 25-year period what did you think the problem was?

KLUMPP: Unexplained.

JOHNSON: You just weren't sure.

KLUMPP: I didn't know what caused that. I didn't know what actually caused it until Russ Larson told me.

JOHNSON: I think what we'll do is we'll stop for today and then come back tomorrow. We'll pick up on some of the other Apollo missions and go on from there on your career.

[End of interview]