David Lehman

September 7, 2021

Erik M. Conway,
Interviewer

Q: Okay.

Lehman: Your audio kind of breaks up, Erik. It's sort of in and out.

Q: Yeah. We've had bad Internet up here for the last few days, and so it's not a thing I've been able to fix.

Lehman: Okay.

Q: So, sorry about that. We may have a good bit of garbling and so forth. I hope not, but we'll see. I've got everything else closed on the computer except Word, so I can read my questions. I think it's just an Internet issue.

So, first off, Dave, how long were you at JPL?

Lehman: How long? Over forty years. November 3rd, 1980 is when I started.

Q: Oh, man, the day before my birthday. Very good. What were your prior projects prior to GRAIL?

Lehman: Let's see. I worked on Deep Space 1. I was the project manager of Deep Space 1, and I also worked on Mars Pathfinder. I was technical manager of one of the subsystems. Let's see. I was a group supervisor, so then I worked on all the projects, essentially. That's about it, yeah.

Q: For projects. Okay. And let's see. I think you told me you were the avionics manager for Pathfinder long ago, though.

Lehman: Right, but we combined two subsystems (Attitude Control Subsystem and Command and Data Control Subsystem) into one; it wasn't called avionics, but that's a good way to catch it now. In today's parlance, it would be called avionics.

Q: So tell me the story of how you became the project manager for GRAIL. It was your second time as a project manager, as you've said.

Lehman: Right. Well, the PI was Maria Zuber during step one, and so she had to pick a project manager. JPL probably gave her a couple names, and she remembered me because I had to give a presentation. When Mars '98 failed, we lost those two spacecraft, NASA hired a committee to investigation what's going on at JPL, and Maria was on that committee, okay, investigating JPL. So I had to give a presentation before that committee on the Deep Space One project, so that's how she knew me, it

was just that one presentation that I gave to her committee.[1] I don't think she was head of the committee; she was just a member of the committee. So that's how she knew who I was. So, anyway, so she picked me.

But for GRAIL, for step one, it was very late when they finally picked me, so my only contribution for the step one proposal was just submitting my résumé. That was it.

Q: What time frame was step one for GRAIL?

Lehman: I don't know. Let me think about that. Time frame for GRAIL for step one. I'd have to think about that one.

Q: Okay.

Lehman: GRAIL launched ten years ago this coming Friday.

Q: Right.

Lehman: It was 9/10/11, and it's coming up on 9/10/21.

Q: So the step one would have been six or seven years before that?

[1] This was the Mars Program Independent Assessment Team, chaired by A. Thomas Young of Lockheed Martin, March 14, 2000.

Lehman: Probably like five years before then.[2]

Q: Five years, okay.

Lehman: I can look it up. I can look it up to find that.

Q: I have your final report, so I can probably look that up too. A follow-up question on step one, though. What had been done at that point? I just want whoever uses this again to understand what is in a step one Discovery proposal versus the next step.

Lehman: The step one proposal is Discovery puts out a call for proposals, and step one is where anybody in the world can submit a proposal, okay, but it's not paid for by the government, so it's paid for by the institution. So JPL—I don't know how many they submitted. I think when GRAIL was under consideration for step one, I worked on two others. I was on two others. The ones I worked on didn't get accepted. The one I didn't work on did get accepted. [laughs]

Anyway, so Maria Zuber, she was the PI, and her deputy PI was David Smith. He's from Goddard. He's retired from Goddard. But Leon Alkalai—you know Leon Alkalai?

Q: Yes.

[2] Announcement of Opportunity was issued January 3, 2006. The Step 1 proposal was submitted in April 2006.

Lehman: So Leon Alkalai, he was the proposal manager/capture lead, and I think he was the one who had the idea for GRAIL. Basically, GRACE had been successful, so really the idea was to put GRACE at the Moon. So Leon had that idea, so it was kind of like it came from his head. And then he had to get the PI and everybody involved, okay, but that was the main thing Leon did, was creating this idea and bringing in Maria and Dave Smith, and then Maria hired the science team. So, yeah, what was good about GRAIL was the step one proposal was excellent, so GRAIL had an excellent birth, okay, and it was championed by Leon and Maria.

Q: That's interesting. I didn't know about that connection to Leon Alkalai. I'll have to interview him about that, too, just as I have to interview him about the ventilator project.

Lehman: Yeah, he was also in charge of step two, of course, too, so that's where Leon and I worked together on GRAIL.

Q: So would he have been the capture lead for step two while you were the manager?

Lehman: Yeah. We didn't call it that. Back then, there was no concept of a capture lead. It was just called proposal manager, but Leon had the role, what we would call now combined capture lead/proposal manager for both step one and step two, for

both of them. So he was the lead guy for both those proposals, step one and step two.

Q: Then you came in later.

Lehman: Yeah. I started on step two.

Q: So you represent the transition. You've already told me my next question, which was how did you meet Maria Zuber. You met her when you did the Deep Space One presentation. So tell me about when you first met her as a prospective GRAIL project manager.

Lehman: Well, she called me and asked me, and introduced herself, "Hey, I was on that committee evaluating Mars '98 and all the other JPL projects, including Deep Space 1." So then we met over the phone.

Then when step two happened, then we started having daily meetings with Maria, writing the step two proposal, so that was mainly all done by the phone, and there was probably maybe three or four meetings when she would come to JPL or there'd be some science meeting, like the DPS [Division for Planetary Sciences] meeting, or the meeting in Houston. What's what science meeting in Houston?

Q: The Lunar and Planetary Science Conference?

Lehman: I think that was the only science meeting they had during step two, the Lunar and Planetary Science meeting.

Q: One thing that's always interested me in Discovery is what's the breakdown of responsibilities between the project manager and the PI.

Lehman: The breakdown?

Q: Of responsibilities. Who does that and who's responsible for what?

Lehman: Well, the way we set it up was, see, back in those days, did you hear about Kepler and Deep Impact?

Q: Oh, yeah, I know about those two, yeah.

Lehman: Those are two Discovery missions, and those Discovery missions, they went through a lot of project managers.

Q: Yes.

Lehman: They don't fire PIs, but they have no problem firing a project manager. So my idea was that—Maria, she said, "My goal for GRAIL is to come up with the best gravity map of all time of the moon." And she goes, "What's your goal, David?"

I said, “My goal is not to be fired.” So that was my goal. That was my goal on GRAIL, not to get fired, okay?

So what we set up was that we had daily tag-ups, so her and I and Dave Smith, we would tag up—and in those days, Leon—the four of us would tag up every day so we knew what each was doing. So that was one of my ways not to get fired, was to make sure that we’re both in the loop. If you’re both in the loop, you know, you can decide whatever you want of who does what, but mainly she was in charge of gathering together the science team and putting together the science section, but she kept the actual proposal really close to the vest. So she was the final approval of everything. She’s in charge. I’m just, like, her assistant, so to speak.

And during step two, the proposal manager and the PI, are the most important parts, the project manager isn’t that important at that time because really my only output was to have the management section done, and we had another fellow do that, so I was just reading everything in the proposal. I wasn’t a writer. I wasn’t the lead author of any one section; I just sort of reviewed everything, but especially the management section.

So, basically, if you’re talking to somebody every day, how you split up the labor is just who’s available and who’s the best at something, so that’s how we set it up.

Q: And that’s throughout the proposal process.

Lehman: Right.

Q: Does it change once you're selected?

Lehman: Well, then the proposal manager goes away, so Leon left, but Dave Smith, Maria, and I continued that process, daily meetings through all development and through operations, daily meetings every day. I would basically tell her, "Okay, this is the disasters of yesterday and this is what we're going to do today. Any questions?" [laughs] So she was in the loop with everything, and she was in the approval loop for all liens. Any expenditures of money, you know, we needed more money for *x*, *y*, and *z*, she was the approver of all the liens, because if you know where the money is, you're in charge. That's different than most project managers on Discovery. Usually the project managers are in charge of the money. In this case, Maria was really in charge of the money.

Q: And so that sounds like an interesting difference. But, man, meeting everybody every single day, I assume every morning or was it in the afternoon?

Lehman: It was 8:00 o'clock Pacific Time, and she was there, you know. People would get sick or go on vacation, but she was religious about that, and plus the meetings to go over the budget, she was ruthless. [laughs] Say some guy, he needed money for *x*, and he'd have to prepare paperwork and he had to give a presentation to Maria and Dave Smith and I, and Maria and Dave were ruthless. So it was like

their own money. It was like their checkbook, and it was, because the PI's in charge of everything, especially the money and the science.

Q: So that really is different than the usual JPL project manager arrangement, because ours tend to be a little closed with what they share with people above them.

Lehman: Yeah, that was different, and that was all part of me not wanting to get fired. [laughs] I didn't want to be like all those project managers on Kepler and Deep Impact.

Q: So you really think that was because they just didn't communicate well? Is that it?

Lehman: I'm sure it was. I'm sure it was. You know, if you're the PI and you find out the project manager changed computers on your spacecraft, "Whoa," you know. "How could that happen without me knowing about it?" I'm sure that never happened, but something drastic probably would.

Q: Okay. Interesting, interesting.

Lehman: So in a way, Maria was the project manager and I was the deputy, in essence.

Q: She's making financial decisions, but not technical ones, right?

Lehman: No, no. She would be right in there with any technical decision. She'd be right in there. She's be right in there with—you know, if there's a big trade study changing out a gyro or something, she would be right there. She would hear the pros and cons and the decision loop for that. We called that our TSC Board. We had a Technical, Schedule, Cost Board, and she was the chairperson of that board, so any technical changes, schedule changes, cost changes, she was the chair of that committee of three people, Dave Smith, Maria, and me.

Q: And then whatever poor engineer that needed to change something, it sounds like.

Lehman: Yeah, yeah, yeah.

Q: So was this TSC board a somewhat special purpose thing or was it standard and continuing through the whole project and other projects too?

Lehman: It was a special purpose group. Most projects, they call that just the Change Control Board, CCB, but we just had a different name for it. Typically we'd have those on Fridays, because most of them were on the budget, so we would do that on Fridays, but they could be ad hoc. If something has to happen today, we'd do it today.

Q: And you didn't extend that membership to the project engineer? It was just the three of you?

Lehman: Just the three of us. If there was a technical lien, then the chief engineer and the project system engineer would support that, but that's very rare. That was very rare on GRAIL, because Maria and Dave Smith, they set up our Level 1 requirements. They never changed. They set it up in step one and they never changed, so that was something that helped GRAIL, was continuity of requirements.

Q: You didn't have the creep that many projects have.

Lehman: No. Marie and Dave Smith were ruthless. Anybody wanted to change anything, forget it. Plus, our chief engineer, he was ruthless also. He would not allow that to happen at all. [laughs]

Q: Who was your chief engineer? I know who your project engineer was, but who was your chief engineer?

Lehman: Duncan MacPherson. He passed away like three years ago, but he was really good. I mean, he understood the science requirements, and he's the only one who could translate those into what engineers can understand.

Q: Oh, that's interesting. He understood the gravity stuff. Because some of that is a mystery to me. Some of it I get, but some of it's just a mystery. You probably know it better than I do.

Lehman: I don't know. It's pretty tough.

Q: Yeah, it's arcane. So let's see. A little bit back to the proposal. Do you happen to know what the other missions you were competing against were?

Lehman: No. No, I can't remember. I was the designated project manager for two of them, and I can't remember.

Q: And you don't remember what they were. Okay. [laughter]

Lehman: Yeah. If I can't remember those two, I definitely won't remember the other ones.

Q: That's fine. That's fine. I'm just always curious about what's the competition, but I'll bet you Maria will remember.

Lehman: Leon would know. Leon would know.

Q: Ah! Okay.

Lehman: Yeah, he's the type of guy who would keep track of all that stuff.

Q: Great. Thank you. So, let's see. Next question is about the team. So tell me about assembling your team once you win. Who do you put in the major roles, and why did you choose the people that you did?

Lehman: Okay. Well, during step two, it was lucky. At the time, I was the head of the Project Support Office. Have you heard of that?

Q: Yep.

Lehman: Do you remember Tom Gavin?

Q: Yeah.

Lehman: So I was his grunt, basically, and so I was head of the Project Support Office. And then GRAIL came, and he allowed me to work full-time on GRAIL. I was on burden [funding] like you, and so I worked full-time on GRAIL for nine months or whatever it was, for step two, and my focus was hiring the key staff. So I put a lot of thought with that, you know, with Leon working on it and Maria and Dave Smith. So in my job, there's like maybe five, ten people or whatever, the key staff, and that's

what I did, was to get the key staff. I wasn't worried about writing the proposal so much, but getting the key staff. You have to put an org chart in the proposal.

Duncan I brought in. Maria and Dave Smith and Leon already [glitch in recording], so we brought Duncan in. He was ordained from the beginning because they knew him so well. Then it took us a long time to find the project system engineer. That's "Hoppy" Price. We had another fellow—we had, like, a near final meeting on the proposal, and this guy bombed out in the meeting, so we had to replace him. So Hoppy Price replaced him. In fact, when we turned in the step two proposal, Hoppy's name wasn't in it [laughs] because we'd just gotten rid of the other guy just before we submitted it.

But, anyway, so Hoppy was recommended, and then both Leon and Maria and I, we all concurred on that, so we got Hoppy, and he worked really well with Duncan, because we'd worked before that on Prometheus with John Casani, so Hoppy was on there, plus Duncan. They were kind of like in the same role, the chief engineer and project system engineer.

Then I had to hire a spacecraft manager, so I interviewed a lot of guys and talked to a lot of people, and we ended up with Tom Hoffman, and he's excellent. Now he's project manager of InSight, and he's the project manager of a new mission. I can't remember what it is, but it's in 8X now.

Q: Yeah, I remember his name coming up again, but I don't remember what the mission is either.[3]

[3] NEO Surveyor.

Lehman: Yeah, I forgot the name of it. Anyway, so Tom was excellent. Then we had to have a payload manager, and that was Charlie Dunn. You know Charlie Dunn?

Q: I don't know Charlie.

Lehman: He was the payload manager. He was also in charge of the instrument, okay, and he was excellent. He had been in charge of the instrument on GRACE.

Q: Right.

Lehman: So he just moved over to do a similar instrument for GRAIL. Then we had a business manager. Her name was Marjorie Raymond. She's in 9X now. Then our 5X lead was Charlie Bell. Leon, Maria, and Dave Smith were in the loop where I was doing this hiring.

So, anyways, I'm proud of that because all those people stayed onboard until their job was done, so there were no transitions, okay? To me, that's a measure of 'I did a good job.' If a person was good and they stayed on—I mean, if they were awful and they stayed on, that would be bad, but they're all good and they all stayed on. So that was my main job in step two.

Then Leon, like I said, he's the proposal manager, but he was also instrumental in getting money for our instruments. During step two, we built a prototype of the instrument, the whole thing, and so when we had our site visit, we

took the whole review team up to the mesa, on top of the hill there to watch how the instrument works. So we already had a working instrument by the time of the site visit, and Leon was instrumental in getting the money, and then Charlie Dunn was instrumental in getting the prototype ready for the site visit. So that was really fantastic that they were able to do that. That was a big feather in our hat, the site visit, having that prototype working of the instrument.

Q: Do you think that mattered, even though—let's see. By the time that's going on, GRACE had been in operation, hadn't it?

Lehman: Yeah, it'd been in operation, but it's still a different—oh, yeah, it had been in operation, but it's still a different beast, you know, different frequencies.

Q: Oh, I see. So it's not just a copy. It was actually a different instrument.

Lehman: Yeah, it's a different instrument. That one relied on GPS. There's no GPS at the Moon, so it's different, but it was very similar.

Another key advantage we had for the site visit was that all the best gravity scientists in the world were on our proposal. [laughter] I mean, when they did the science evaluation, there was nobody to pick [laughs] to evaluate us.

Q: There were no hostile reviewers available with the right competency.

Lehman: Right. We had them all, okay? So they didn't know anything about our instrument. All they knew is the best people in the world were saying it's good, our science is good. That's it. So they really couldn't give us a thumbs-down when they didn't know what they were talking about. So Maria and Dave Smith did a good job finding the right people for the science team.

Q: Very cool. Let's see. Who else was on your project team? You told me about five people, I think?

Lehman: Let's see. We had Marjorie—

Q: Duncan, Hoppy.

Lehman: —business manager, Hoppy Price, Duncan MacPherson, Tom Hoffman, and Charlie Dunn. We had a chief engineer for the instrument, and this name was Bill Klipstein. Bill Klipstein, he was the chief engineer for the instrument. Remember Deep—what's the name of that atomic—

Q: Deep Space Atomic Clock?

Lehman: No, no, not the atomic clock. What's the other one? The laser communications.

Q: There was a laser communications demonstration on—was it on MRO?

Lehman: No, no, no, no, no, no.

Q: There's OPALS in Earth's orbit.

Lehman: No, no, no. My brain's not working. I'll remember it in a minute. Okay. There's Deep Space Atomic Clock, there's Deep Space using lasers for communication, Deep Space Comm, and that's on one of the Discovery missions. What's the name of that?

Q: I don't have any memory of that. I'll look this up.

Lehman: Optical Comm.

Q: Deep Space Optical Comms?

Lehman: And that's on one of the Discovery missions, and Bill Klipstein is the project manager of that. Deep Space Optical Comm.

Q: Is it Lucy or Psyche?

Lehman: Yeah, it's on Psyche. So, anyways, Bill Klipstein, he was the lead engineer or whatever for the instrument, and so then he graduated to become the project manager of Deep Space Optical Comm on Psyche.

Q: Interesting. So those are the major people. Who were your major subcontractors and how did you choose them?

Lehman: Okay. It was Lockheed Martin, and during step one, Leon did some sort of evaluation of potential contractors and they picked Lockheed. So that was done before my time. Then the project manager at Lockheed, his name was John Henk. Yeah, John Henk. Then the lead engineer, their chief engineer was Stu Spath. Stu Spath eventually became one of the super head guys at Lockheed. He's since retired.

Q: He's since retired too?

Lehman: Yeah.

Q: Don't know that I'll get to talk to either of them. How did you handle communications with Lockheed during the project? Were they part of the daily phone conversation too?

Lehman: No, the daily conversations were just between Maria, Dave Smith, and I. So, anyways, so I hired an excellent spacecraft manager, Tom Hoffman. He took care of it.

Q: He did that. Okay.

Lehman: He did that, and that wasn't my job.

Q: That was in his portfolio.

Lehman: Yeah, yeah. But during development, we would have monthly management reviews at Lockheed, and then we'd always try to have a management meeting just with the managers. If Maria was there—well, she would support those meetings also with Lockheed, when we were at Denver.

Q: That was the question. So when you were out in Denver, you also met with the management separately, which makes sense.

Lehman: Yes. Lockheed was great. They underran the project. Yeah, they were on schedule, so they're great.

Q: Now, let's see. There's still another management aspect with Discovery, and that is you have program executives at headquarters and a program manager at Marshall Space Flight Center. So talk about those relationships during GRAIL.

Lehman: Okay. Well, what we did is we would have weekly meetings with the Program Office at Marshall and the program executive at headquarters, and so in those conversations it'd be those two guys, Maria, Dave Smith, and I. So those were done every week. It worked out fine. It worked out fine.

Q: What kind of information are you communicating in those? Are they just status updates? I mean, I'm sort of grasping at how to understand the need for a weekly meeting and what you're telling them.

Lehman: You're telling them the status of the mission, but basically you're always coming up on a next key decision gate, like getting ready for PDR, CDR, so you're going over the status of readiness for that, all right? Like, for example, a PDR, that's a really big deal for a project manager to get ready for, so you'll be communicating with them on the status of all the products that are due, like a PDR presentation, and then a briefing to the head shed [the Director's Office] at JPL, and similarly with headquarters. The program executive has got to prepare a lot of paperwork, and then that guy, he would work with the Program Office to get that done. So the Program Office is really kind of like the program executives' grunt. They get stuff done. And whenever there's some kind of weird headquarters requirements, they

would try to buffer it so it would have less effect on us. So they would try to end-run it or smooth it over so it wouldn't cause a lot of turmoil, or hopefully try to do whatever they needed to get done anyway. So the Program Office was very helpful in that.

Q: So you saw them as a benefit. You saw the Marshall office as a benefit.

Lehman: Yeah. The Program Office was very good, yeah. It was Rick Turner. There was three of them, and they were all good. Then this guy Bill Knopf, he was the program executive at NASA HQ. He was very good too. Bill was excellent. Yeah, I really enjoyed working with Bill, all of them, really.

Q: All of them. So sounds like you had a largely good team of people you had to work with.

Lehman: Yeah. We didn't have any mental cases at all.

Q: No real problem children.

Lehman: No. So we were blessed at the beginning. [laughs] When they picked us at end of step two, we'd put in there we wanted a regular Delta rocket, and they gave us a Delta Heavy rocket, okay?

Q: Wow.

Lehman: And so that was really nice having that extra mass. [laughs] So it was great.

Q: Yeah, it saved you probably a lot of money from trying to shave mass off the spacecraft.

Lehman: Yeah, so that turned out—like I said, GRAIL had a really good birth [laughter], Leon writing a good concept and then having an extra big rocket.

Q: In your final report—I haven't read all of it, but I've read a lot of it so far—you complain a lot about reviews, lots of excess reviews and so forth. So my first question is a little bit historical. What do you think was the trigger for all the reviews?

Lehman: No, it's just normal. All projects have a lot of reviews. [laughs]

Q: So you didn't think anything had changed from your prior experience, right? Because you were Deep Space 1 project manager. So did you think your review status was worse—

Lehman: Oh, yeah.

Q: —or the same?

Lehman: Well, Deep Space 1, that was during "faster, better, cheaper," so we cut corners on everything, but what we did on GRAIL was typical of a Discovery project, but it's still a lot.

Q: Still a lot. You mentioned that you were the first project to operate under this NASA Standing Review Board requirement? Did you mean the first project at JPL? Where did that requirement come from?

Lehman: Oh, yeah. See, there was this thing called the NASA Project and Program Management Requirements. I can't remember the number of it. [NASA NPR 72120.5] Gavin and I worked on the latest version of that, okay? Gavin was in charge of that. So that's when they came up with the concept for the Standing Review Board, was in that document. We had just finished writing that document and getting it approved by NASA, and so then we were the next one. We were the first project after that with the Standing Review Board concept. We already had Standing Review Board, but it was just more formalized.

Q: Oh, I see. So it was a thing that already existed, and you altered it to make it more formal.

Lehman: More formal and with—I'm trying to think of the right word. More formal and it was more independent. I mean, a JPL project just couldn't pick all of—say I was a project manager and I wanted to have a Standing Review Board. I'd pick all my buddies. [laughs] NASA didn't want that. They wanted more independence, so that happened. Cheryl Reed, she was the Standing Review Board chair. She was from APL.

Q: Okay. Because I remember Tony Spear had something like that [on Mars Pathfinder], but it was Tony's people that were on it.

Lehman: It was Tony's people, yeah.

Q: So that was a self-inflicted review, I guess, in that sense. You changed the terms of it to make it—well, frankly, more, as you say, more formal and probably also more reliable.

Lehman: Right. Then they had people on the payroll to do cost analysis and schedule analysis, so that was part of the funding that went into the Standing Review Board to actually fund that effort to do more independent analyses.

Q: Okay. Yeah, that's good to know and interesting. Let's see. I have to ask this question. Well first, what reviews are actually under the purview of that review board versus other JPL in-house sorts of reviews?

Lehman: I would say all the reviews that are before a gate change, like from Phase A to B, and B to C, the Standing Review Board is the review just before you change from Phase A to Phase B. That's a gate review, okay? So that's a whole mission review. But then all the reviews for subsystems and systems, those are under the purview of the project manager. So if you're having an attitude control subsystem review, that's under the purview of the project manager to stand up, but if you're getting ready for KDP-C, you know, you have to go in front of the Standing Review Board before you can go in front of NASA to say you're ready. They have to concur with that based on the review.

Q: So this is probably a dumb question because it shows you how far I am from the engineering world, but what's the relationship between the KDPs and the things we call CDRs and PDRs? Are they the same thing or are those just—what's that relationship?

Lehman: No, no, no. For KDP-C, Key Decision Point C, this is the decision point to go from Phase B to Phase C, from preliminary design to detail design. So at the assembly level and subsystem level and system level, you'll have PDRs at a low level, okay? And when you're done with that, then you have the big one, the big PDR in front of the Standing Review Board, okay? And that's looking at everything, not only the technical stuff, but the schedule and the cost. So then that's an evaluation by an outside group of whether you're ready or not to go into a key decision point.

The Standing Review Board writes a report. Then the project gets a draft of the report for them to comment on. Then if they say, "Yeah, you're okay," then you'd have to go in front of the Director's Office. There would be a review, okay? So you would tell them their status so the director knows, yeah, project manager thinks he or she's ready to go. And Maria would be in that meeting. That was usually led by the deputy director, so nowadays it would be Larry James.

Then if you get the thumbs-up from that group, then the next step is to get the okay at the headquarters level, and that's the real key decision point, okay, when you go in front of headquarters.

So then the program executive working with the Program Office at Marshall, they would prepare paperwork saying that, yea, verily, you're ready to go into—you're passing this Key Decision Point-C, okay, and at this point is where, the KDP-C, this is where you're officially assigned your budget and your schedule and everything. Everything up to that is preliminary. In fact, you remember Rick Grammier?

Q: Yes.

Lehman: He was the head of 4X then, before he passed away. So in that meeting with headquarters, he just said, "Hey, I think they need another 10 million."

"Why?"

"It's just my gut feeling, just looking at all this stuff and this and that. They need another 10 million." So we got it at that meeting.

So the head of the Science Mission Directorate was Dr. Ed Weiler at the time. He said "Okay." They gave us the 10 million. So that was great.

At the time, we were saying, "We don't need it," but we really did. [laughter] We didn't really need it, but it was nice to have another ten-million-dollar buffer.

Q: Yeah, to add into your manager's reserves.

Lehman: Yeah. So that was nice. Rick Grammier, he did that. That was a key thing he did. The other thing is we had a cash flow problem prior to that. We looked in the checkbook and we needed another 10 million. What are we going to do? And so he was able to get 10 million from the rocket transferred over to us temporarily to get us through this cash flow issue. So that was the two key things Rick Grammier did, bless his heart, for GRAIL.

Q: Was that a time phasing issue?

Lehman: "We need the 10 million now, but we don't need it later." That was all. So it wasn't an overrun. The money was there, but in the future. We needed it now. And the rocket people didn't need it.

Q: They needed it some other time, probably, too.

Lehman: Yeah.

Q: They needed it later. [laughs] Okay. So still on the subject of reviews, how do you think the reviews helped you?

Lehman: How did they help us?

Q: Yeah.

Lehman: No, there's no help from a review. It's just the preparations getting ready for it. That's all that matters.

Q: So they didn't identify any issues?

Lehman: Well, they probably did, but usually that's the secondary item. It's just getting ready for the review was the main thing.

Q: Getting ready for the big review forces you to carry out all the subsystem reviews, and that's when you find things?

Lehman: Yeah, yeah. Everything's found then. I'm sure there's places where there's good advice, but I can't think of any right now, but I'm sure there were.

Q: Okay. So let's see. Next question. Again, in your final report you emphasize heritage when you started out the project, because you had GRACE heritage, and I understand the Lockheed spacecraft had some heritage as well. So talk about that in your flight system and project. How did that heritage argument play out?

Lehman: Well, heritage means that you're standing on the shoulder of giants, I guess, trying to take advantage of past work, and so that worked out really well for us with the GRACE and with the Lockheed spacecraft and with the MoonKam instrument. They helped in all those areas. We didn't have to do new—the amount of new developments was really low.

Q: So the heritage argument was meant to reduce your technical risk.

Lehman: Right, right. I mean, if you're using the engine in your car and you got it from an engine used in the same type of car from five years ago, it's good. It's the same thing. You want to keep using that engine if it works well. [unclear] [00:47:44] your battery. You want a good battery from the past car for the future.

Q: You want a battery that's recent but not too heritage, because then it won't work. [laughs]

Lehman: Yeah, yeah.

Q: They do have a limited capacity. But the reason I ask is that many JPL projects start out claiming a lot of heritage and then it just gets washed away in development.

Lehman: Yeah, so we're lucky with Lockheed. Lockheed doesn't allow that. I mean, for each of their missions, they're just a small delta from one to the next, and they just slowly do--whereas JPL, they just go, "We're going to just change everything here." Well, they have to make a profit, you know, and they can't overrun like crazy. And Discovery's very sensitive to cost growth and things.

Q: Yeah. It's supposed to be a cost-capped line of missions.

Lehman: Yeah, yeah.

Q: Let's see. You're also one of the earlier projects subject to the new Design Principles and Flight Project Practices. So did those impact you?

Lehman: Yeah, but they're fine. We didn't have any problems with those. We didn't have any problems. They were good guidance. Yeah, so that worked out well. [unclear] [00:49:14].

Q: I didn't mean this in a negative sense that it caused you problems, but I'm trying to get at maybe the opposite. What did they do for you?

Lehman: Well, no, no.

Q: Or did it not matter?

Lehman: They were good guidance. They were all good things to do. We had very few waivers. I'm trying to think. We had one giant waiver. Can't think of what it was.

Q: Was it from single-string?

Lehman: It must have been. It must have been our single-string waiver that we had to get approval, but there was another waiver. I can't remember what it was, but we had to go all the way up to the director. Dr. Elachi had to be in the meeting. It had to do with something simple. The sentence was an "and" or an "or." It had something to do with you need to test it this *and* that. We did this *or* that. It was something really simple. We had to go to the Director's Office for a waiver between the words "and" and "or." [laughs]

Q: Jeez.

Lehman: But I can't remember what it was, but it was funny at the time. "We're going to the Director's Office for this?" It was some test, some test that we were doing.

Q: I see. So then it's probably in your final report somewhere and I just haven't got to it yet.

Lehman: I don't think we'd have that kind of detail, but there was some test where we wanted to change the word "and" to "or." [laughs]

Q: I see. Okay. Let's see. Last question for this interview before I go chase after some other people. What would you say were kind of the key events on GRAIL, from your perspective?

Lehman: I would say the launch, 9/10/11, and the final day, that was 12/17/12. Yeah, December 17th, 2012, that was the impact. That was when we were trying to hit Sally Ride Mountain, okay, and that was really—that was something. [laughs]

Q: Well, tell me about it. From the project manager perspective, it's a little unusual that you were still involved, because a lot of times at JPL, the project manager during development leaves, but you didn't.

Lehman: Yeah, I stayed for the whole mission.

Q: Tell me that story.

Lehman: So what it was is, okay, Sally Ride, she was in charge of our EPO, and she had passed away like six months beforehand, okay, and her family was at the event when we were doing the commanded impact. So we wanted GRAIL to impact the Moon on not the far side, but the near side, okay? And we wanted to impact—the place of impact we wanted to call Sally Ride Mountain, okay, so we had to hit this mountain.

The problem was that just before that mountain there was another mountain, okay, so there was a mountain here and a mountain there, and we're coming over this way and want to hit this one and not this one, okay? So that was the key thing we were trying to do. But at the same time, we wanted to do an experiment. We wanted to determine how much fuel we had left in our fuel tank, okay? And so we did a controlled burn to depletion.

So, anyway, so we're coming up on this mountain, and at the same time we're doing a controlled burn, okay? So how are we going to do this burn at the same time we're trying to maintain our momentum to hit this mountain and not that mountain, okay? So that was unbelievable. Our mission design manager was Ralph Roncoli. You know Ralph Roncoli?

Q: I know the name, but I don't think I've ever met him.

Lehman: He's just maybe retired. He's about ready to retire. He was our mission design lead, so he came up with that concept, okay?

So anyway, so that was a pretty key event. We're thrusting this whole time. We don't want to hit this mountain, but we want to hit that mountain. And we don't want to go on the far side of the Moon. Otherwise, we didn't hit anything.

I forgot one key person, Erik, and that was our mission system manager, and that was Joe Beerer. He retired just after our impacting the Moon.

Q: Right. I remember Joe. Not sure I ever interviewed him, but I remember. Okay. And no other key events then? Just the launch and then the collision.

Lehman: Yeah, those are the key events for me. I mean, all these reviews and everything, but those pale in significance—insignificance.

Q: Very good. Not even the arrival at the Moon? Because you had a somewhat crazy trajectory.

Lehman: Yeah, we had a crazy trajectory to get there, and that was all due to minimizing—what was the reason for that? First of all, we wanted to have the orbit insertion done the same day, regardless of the launch date, okay? Regardless of the launch date. That was kind of the main thing. So we could launch thirty days later and still have the same arrival date, okay? Those arrival dates were like January 1st, 2012 and January 2nd, 2012.

Q: Yeah, they were only a day apart.

Lehman: Yeah.

Q: I would have thought the other reason would be—but I don't remember this from your report, but fuel savings, because direct ascent trajectory to the Moon, you need a lot of deceleration fuel, I would think.

Lehman: That's another reason, is reduced fuel usage.

Q: Since you have to carry it all. Okay. I have a last question before we sign off that's not particularly a formal one. Do you think Monique would be willing to be interviewed for this? One of the questions that the Discovery Program manager at headquarters asked was can we also interview families.

Lehman: Sure.

Q: To see how *the family* takes having Dave have an 8:00 o'clock meeting every morning for four years.

Lehman: Yeah, I'm sure she'd be okay with it. [laughter]

Q: Okay. Then I can do that. Maybe it'll work better in person. Who knows. We'll see how things all fall out.

Lehman: Okay.

Q: Thank you for your time, and I will stop recording.

Lehman: Okay.

[End of interview]