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ORAL HISTORY TRANSCRIPT

JAMES W. HEAD, III
INTERVIEWED BY REBECCA WRIGHT
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WRIGHT: Today is June 6, 2002. This oral history is being conducted with Dr. Jim Head at Brown University in Providence, Rhode Island, for the NASA Johnson Space Center Oral History Project. The interviewer is Rebecca Wright, assisted by Sandra Johnson.

Thank you again so much for taking time from your busy schedule to visit with us today. We'd like to start with you telling us what sparked your interest in geology and planetary geology in particular.

HEAD: Well, I'd always been interested in the outdoors and just getting outside, the rocks and so on. I guess really what sparked my interest in geology was when I was a freshman in college at Washington and Lee University [Lexington, Virginia], I had to take a science course. So I looked in the catalog and all the labs were inside, physics, chemistry, biology, and [for] one of these [courses], geology, all the labs were outside, and I said, "Hey, that's for me." I had no clue what it [was] all about, because they didn't have geology in [high] school. So, actually, that really got me interested.

I took it my freshman year, and by the end of that year I was just totally in love with it. I had the opportunity to go to Montana at the end of that year to work in the field as a field assistant, and the professor [Dr. Ed Spencer] said, "You're either going to come back loving geology or hating it," and I loved it.

Then I came to grad school, actually, here at Brown, and Thomas [A. "Tim"] Mutch, who went on to become the Associate Administrator for Space Science, was a geology professor here, and I started to work under him. He wasn't interested in planetary at that time, but over the next couple of years he became interested in it.

People like Gene [Eugene M.] Shoemaker came and gave lectures. This would be '67, '68, somewhere in there, and it was very exciting. So we had a few courses on remote sensing and how you take the principles we were learning about the Earth to turn them to Mars or Venus or the Moon and how you would use the same things to understand the geology there, and that got us all thinking. We actually had a graduate seminar in which there were three people in the class and two of them went to become—[R. Stephen] Steve Saunders is the other one, he went on to become the mission scientist for Magellan and Odyssey presently and so on. So it was a very productive time and influenced a lot by Tim Mutch.

I guess, for me, really, what [got] me into doing planetary geology, [and] there really wasn't a field of that [type] at the time, was that [during] my last year in graduate school, Tim had gone off to work at USGS [United States Geological Survey] at Flagstaff [Arizona] on a sabbatical, and I was thinking, what am I going to do? Am I going to go to teach at some small university or work for an oil company? Because my [Ph.D.] thesis was on Earth, not on the planets. So I was looking through a college placement annual, which is a book that has career information for potential people in a whole range of areas. I looked up geology in the back, and there was an unusual name I didn't recognize. I turned to that page, and there was a full-page picture of the Earth's Moon, from, you know, Earth-based picture of the Moon, and it just said, "Our job is to think our way to the Moon and back. If you're interested, call this number." Well, whoa! Okay!

So I called that number, and it happened to be Bellcomm [Inc.], which was the systems engineering organization at NASA Headquarters. I got an interview. I went down there, and they offered me a job. It was, like, unbelievable. That ad, I wish I'd kept it, of course, but it was just one of those things that was just completely engaging. How do you get to the Moon, let alone, how do you think your way to the Moon and back?

In a sense, this term epitomized systems engineering, which, of course, I had no clue what that was about at the time, and it was just really becoming a well-established field of endeavor, and that epitomized it: you have to think your way to the Moon and back before you even take one step to get there. In a way, you have to have all the considerations and all the systems together, really figure out how they're going to fit together so you can actually do the job.

That, actually, was really important because that's exactly what Bellcomm did, and, for me personally, it was just amazing to parachute into a bunch of people, engineers, scientists from all disciplines, who were looking at these things from a systems engineering standpoint, whether they knew it or not, and the real systems engineers, which were the people from Bell Labs and the NASA people, were integrating it together in such a way that it worked, in that sense.

So that was just amazing for me, and it probably completely shaped my thinking about how I approached science from there on. So, I can remember, it's like one of those things, like, where were you when [President John F.] Kennedy was [shot], whatever, or something like that. It's like, my gosh, that page, [with the Moon picture and the question,] opening that and seeing that was a real amazing thing, and there was so much depth in that, I didn't realize it at the time. So I was sold at that point. I got the job, and I've been in planetary science ever since.

WRIGHT: You started, and what were your first duties for Bell?

HEAD: Well, when I first went there, again, this was—I can't even remember the date, actually, probably '68, somewhere in there. I can't remember exactly. But my boss at the time, Dennis James, said, "Well, you know, we usually give people about a month to just read up on things, but we don't have time to do that anymore. So, here. We need to have six backup landing sites to present to Congress next week [for] after Apollo 11." It was, like, my god, what, "Sure." I was too dumb to say, "I don't know what I'm doing." I said, "Okay."

So it was a lot of on-the-job training. It reminded me of the Berlitz [International] method of teaching languages, like total immersion. You just got thrown [into] the deep end of the pool, and it was amazing. I'll never forget that at the end of the first day, I was just total adrenaline, like, "I've got to do this. I've got to figure it out. I've got to learn the Moon. I've got to do all this."

It was at NASA Headquarters in the L'Enfant Plaza [Washington D.C.], and at the end of the day I'm looking for the light switch to turn the lights off. I couldn't find it. I didn't want to leave the lights on; that wouldn't be good. But I didn't want to ask anybody, "Where the heck is the light switch?" because, like, how stupid could you be? [Laughs] It turned out it was one of those buildings that was built at the time before the energy crisis, where there's one big switch down at the end of the hall and you leave them on all the time till somebody comes along and turns them off. But it was, like, one of those things. It would make my first day at work, I don't even know how to turn the lights off.

But that's the first things we did, was basically look [on behalf of] NASA Headquarters at future landing sites and things like that. That quickly evolved into—I mean, the other detailed

studies were going on at that time. It's just that I wasn't involved in it in the first week. They gave me these things right away.

WRIGHT: Were you with a team of people, or did they give you this as a solo project, to come up with—

HEAD: They really gave it to me to do, and I think it was obviously something that where there were enough people around to do mid-course corrections [if I got into trouble]. But it was just, like, a good thing for total immersion. The boss knew that I would have to quickly learn the Moon, quickly learn the capabilities, quickly understand what work had gone on beforehand, and picking out sites to that level and so on, and that's exactly what I had to do. So I had to go around and ask people and think myself and so on.

Then in retrospect, I can see that from that they were watching me and how I interacted, what kind of questions I asked, etc., so they could best use whatever talents I had to fit into the right place. So I did end up soon thereafter getting into the geological traverses, mostly the surface geology, into background studies for landing site selection, for doing geological analyses and mapping to help support the USGS people who were working on those as well, preparing information analysis of all the images that were coming, to think [about locations] for future landing sites, and then astronaut training, both in Houston, [Texas,] and also we took them out in the field a lot, the formal site selection process, and then, also, as time went on, much more deeply involved in the traverse planning as we got towards the "H" and "J" missions where, actually, there was a lot more opportunity to spend time on the Moon, where you were then able

to actually do these kinds of complicated complex interactions. Then we'd apply system engineering to surface operations as well.

Then at that point I got involved a lot in the field trips, training in the classroom, going to the Cape [Canaveral, Kennedy Space Center, Florida] when the crews were at the Cape getting ready to go. For [a given] mission we'd go there and do the last briefings for the last month. While they were at the Cape getting ready, we'd do those in the evening. Then at the same [time] we were picking future landing sites, while we were training the crews who were going to be up next in the field, and then mission operations. Whenever there was a mission, I would go to Houston and be in mission control for the operations, and then, of course, with the data analysis [in the Lunar Receiving Lab (LRL)], when the data came back, and also all the simulations, too, played a big role in that as well. It is hard to imagine in retrospect that we were doing all that at the same time, but somehow it worked. [Laughs] It was pretty amazing.

WRIGHT: Well, would you like for our particular interests of today take these and break these down some and talk about some of these sections at one time?

HEAD: Sure. Okay, let me just look through here briefly. We could press on by that if you'd like. Yes, in terms of my background knowledge of the space program, I was really scared because I actually hadn't finished writing my thesis when I started to work there. So in the evening I had to go home and type, type, type away on my thesis. At the same time, in the day I was just operating completely on the Apollo things and traveling and stuff like that. And I didn't know anything about the Moon.

But it reminds me of that Indiana Jones movies where, you may remember that, where they're kind of like, there's stuff flying, Nazis everywhere, this and the other thing, and then there's this pit of snakes, and it's, like, the woman turns to Indiana Jones and says, "What do we do now, Indy?" and he says, "I don't know. I'm making this up as I go along." You know that great line? In retrospect, that's what we were doing.

It's not as cavalier as it sounds, you know. We were really learning as we went along, and a couple of your questions in here are really important in the sense that the feedback was very real. You were finding out something about the results of one mission, and that factored it into the field training and into the planning of the traverses and so on. So there was a big lack of knowledge when I first came in. I still work on site selections for these missions to Mars and things like that, and I keep having to remind people, "You know, we landed Apollo 15 with forty-meter-resolution images." I mean, you know, they're worried about micron-scale studies. It's just amazing.

But we quickly learned, and I think, in retrospect the reason I got hired was because I had a good general education in geology, and what that meant was you were something of a geological problem-solver, not necessarily that you had specific knowledge about the planets or the Moon. I think an astronomer who might have known more about the Moon than I did, from some points of view, wouldn't have been as good a person in this job, because it was the kind of, like, understanding the geology and how geological processes work and how they come together that was going to be so critical in the crew training and the site selection and actually integrating everything together. So [in retrospect] I feel a little bit better about not knowing much at the time.

Yes, it's just a question about the relationships between systems engineering and geology. I think one uses a microscope as an analogy. You know, you can be looking down a tube at a microscope and have a very collimated, specific view. A lot of science is like that, where you're really trying to understand the detailed relationships between things. But on the other hand, if you step back, in the final analysis what you're really trying to do, broadly speaking, is put all this together in understanding how the Earth works, where it's been, where it is now, and where it's going. So it's a system, big-time.

It's only been in the last couple of decades that people fully appreciated how much of a system the Earth is, with plate tectonics and the atmosphere and the overall evolution, how everything's linked together … and the role it [this interconnectedness] plays. So, in a way, it's perfect to apply systems engineering to a planet, because it's cause and effect. It's input, output. It's all those same kinds of things.

So, for me, I think it's guided my approach to research, to stop, think about what the problems are, what's going in, what's coming out, what's cause and effect, and how do you address these questions, and how can you get them, what do you need to understand that, those types of things that were exactly what we were doing then. I think it's become more a part of geology now than it has in the past because people are really beginning to see the interconnectedness.

And that's for the Earth, and, of course, when you step back and look at the neighborhood, which would be the solar system, it's even more that way. You have to understand that. That's why we study Mars, because a significant part of Earth is missing. It's been destroyed. So Mars preserves some of that record and so on. So it's just tremendous, I think, relationships between systems engineering and geology, and I don't think it's really fully

appreciated. It's just kind of like, oh, yeah, that's the way it is now. But it's been a real evolution.

The questions that were being asked at the beginning of the Apollo Program were very, very basic. They were, had the Moon ever undergone extensive melting or not, what is the origin of the Moon, what makes up the dark materials versus the light materials. It was just pretty basic. So, obviously, with the combination of exploration techniques, what the Soviet Union did with automated sample return and Lunokhod rovers and things like that, as well as the clear, clearly very, very important Apollo missions, it's just completely—it's just a whole new—the Moon is now a cornerstone, really, maybe even a keystone in the understanding of the rest of the planets, because right now I'm working, for example, on the history of water on Mars.

The total model for the crust of Mars is taken directly from the seismic data about what [the] crust look[s] like from on the Moon, because we [put] got seismometers all over the place [on the Moon], we have some information on the structure of the Moon, and so our whole model. We have none of that from Mars. So we say, "Okay, here's a planet that's a lot more like the Moon than it is like the Earth. So we'll take the Moon thing and transport it directly." If we hadn't had that information with Apollo, we'd be totally clueless, totally clueless.

So, you know, it in many ways is a keystone. It's a simple—it's not simple, but it's not complicated by the atmosphere and by water and all these other things you see. It's not complicated by the high temperatures … of Venus or Mercury. So it's like a baseline from which we can then look at that other planetary bodies and get some perspective about what's going on.

You can't do that from the Earth because it's so active, and so much of the early record's destroyed. So that's why it's so important. We know an immense amount about it now, and it's helping us to understand the other planets. So that's where it is in my mind at the present time.

WRIGHT: You did have so much to do at one time at the beginning. Were you given priorities? For instance, you started out by having to come up with landing sites for Apollo. You knew that was a priority. You had started to tell us about your way of defining how to start doing this. Maybe you could walk us through the process and how that ended up.

HEAD: Sure. I think a lot of it had to do with just simply identifying what the big questions were, because there was this constant pressure, on the part of systems engineering, actually, where do we want to land? Well, you just can't say. The engineers were all trying to find areas that were safe to land, which was their job. But that didn't mean that it was the best place to land; it just meant that they felt that you could safely land there.

So almost immediately there was introduced two parallel tracks; where do we want to land because of science, and where do we want to land because of engineering and crew safety? As you might always predict to be the case, they were totally orthogonal, in a way, because the engineers wanted to go to the smoothest, flattest, most reasonable flat places, and the Rocky Mountains and Kansas aren't exactly the same thing, you know.

So we would try to ask the big questions, and people like Noel [W.] Hinners were very, very instrumental there. Noel was my boss. Actually, there was a succession of people who served in that capacity, but Noel was early on my boss, and then later on my boss' boss and so on. But he was very good at thinking about the big picture. How do we know if it's melted or

not? How do we know if these are big impacts or volcanoes or whatever? What is the question? And then where will we go geologically to try to address that?

So there was a level of really large questions that were being asked, and there were meetings and discussions with key scientists about this. I can remember discussing this with Harold [C.] Urey, who was really the father of planetary science in a lot of ways, whether the Moon was hot in the interior or not. So we had these kinds of discussions, and there were meetings at which scientists would be brought together to discuss these things.

So there was a Group for Lunar Exploration Planning, called GLEP, and that had a whole bunch of people from different disciplines on it, that covered the range of disciplines that were interested in lunar science, but also people came to those meetings who just had a general interest in the questions. We got a lot of background about what the important issues were.

Then most of these people didn't know a lot about the details of the Moon. Many of them didn't. So there might be somebody who was a seismologist, who wanted to study the interior of the Moon. They couldn't care much about what the surface looked like. They just wanted to put the seismometers in a big triangle. That's it, okay? So these were clearly not the people who were going to be the best people to tell you where the final landing site ought to be, because if there were already two, you knew where the third was going to be. It was going to be at the biggest triangle you could make from that.

So there were people who began to be really knowledgeable about lunar geology. Most of them were at the U.S. Geological Survey in Flagstaff and Menlo Park [California]. Gene Shoemaker started that branch, and there were a host of other people, like Gordon [A.] Swann, Bill [William R.] Muehlberger, who participated in that, but also people who were doing

mapping, like Danny [Daniel J.] Milton [phonetic], Mike Carr, Desiree [E.] Stuart-Alexander, Jack [John] McCauley. Don [E.] Wilhelms is the father of lunar geological mapping.

So they really had been looking at the Moon through telescopes and trying to understand it from a geological point of view. So they were really some of the key people that said, "Okay, here's how we think it works, and here's where we'd suggest." I think Noel [Hinners] was chair of the Group for Lunar Exploration Planning for a while, and he would get these people together to present both the big ideas and the geology, and then our job was to try to make sure that it got put together in a systematic way.

Bellcomm was in an unusual position in a lot of ways. This is my view, now. In many ways it was detested by other parts of the program because the people at the Johnson Space Center [formerly Manned Spacecraft Center, Houston, Texas] thought they were running the program, and indeed they were in many ways. The people at U.S. Geological Survey thought they were doing the geology, which they were in many ways. And the people at Headquarters felt that they needed some kind of organization to make sure that all this was coming together, because they weren't just administering. They wanted to be sure. [Laughs]

So that's where Bellcomm came in, to do the systems engineering and to really make sure that everything was going right. So, in a way, that was a really smart thing to do, with such a complex goal as getting to the Moon and back safely and actually doing some exploration. But it created kind of some resentments, too, for sure. The people at Johnson Space Center were scientists. It was a lot of competition and jealousy, in a way. The role, who's actually doing this, who should be doing it, and so on.

Our role was to make sure that it all came together. So, in a way, we were a layer on top of this chaos in a way. It wasn't total chaos, but there's these rumblings that were going on

between the scientists at Johnson Space Center and those at the USGS. They were always kind of, like, banging around. Then on top of that, the Apollo Spacecraft Program Office [ASPO], the people who were running it in Houston versus the people who were doing it at Headquarters and back and forth.

I can remember Rocco [A.] Petrone, who was the Director of the Apollo Program, saying to me one time, "I want you to go out there and make sure that this is happening and happening in the right way". So he's the boss, and that's essentially, I would say, the role that Bellcomm played, just make sure everything's going right. So, in a way, that was a lot of fun because you got to participate in almost everything. But you had to, at the same time, I guess, establish your own credibility with these people, because they saw you as an interloper in some ways, you know, just initially, a Headquarters spy or whatever, you know.

But for me, I guess probably naiveté went a long way in a sense that most of this stuff I didn't realize. I was just trying to do my job, so I built up what I think in the final analysis were good working relationships with the people at JSC and at the USGS and elsewhere. So it actually worked out really well, and I think I become one of the number of people who could move between all the different things and not be kept out of the loop, but actually do what I was supposed to be doing.

For example, one of the key people in the program was Jack [John R.] Sevier. Jack was the Apollo 11 mission engineer, and he's one of the most amazing people I've ever met. Well, you can imagine if you were the Apollo 11 engineer, you had to have a sense of calm about you, when they come around the loop, to be sure that the flight directors do to be sure that everything's okay. Basically it's your responsibility to make sure that it all happens, right? He was one of the calmest and most reasoned persons. I never saw him really raise his voice in

anger, you know what I mean, and that was just the kind of balance you needed in this kind of environment.

Jack and I hit off really well, and we worked a lot together. Because he was an engineer, we ended up with H and J—well, for the J missions, really, being a team of people who tried to blend all the requirements together, make sure that the traverses were put together in a way that were reasonable, and then we'd go sell them to people. "Okay," we'd say, "Here's the basic guidelines. This is what we can do on the thing. Let's work it out, and so let's work out a traverse here," with the USGS people, and then we'd have to take it to the—we'd go back and forth and give these presentations all the way around, modifying things as the responses came in, and just keep going around until we basically got it right. Then we'd tend to present to the crew in the training area, too.

So Jack worked for the Apollo Spacecraft Program Office in Houston at that time, and we spent a lot of time together, I mean a lot of time. People at Headquarters like[d] this because they knew they were right in it. If I knew, they knew, and I don't mean that in a spy sense. It's just they had also, I think, confidence, in retrospect. I wouldn't have said that at the time because I didn't know what I was doing in a lot of ways, but I think they at least felt that they knew that I was in on these various things. So Jack and I, I think, were able to bridge a lot of the potential problems that existed there, certainly on the J missions.

So we spent a lot of time basically traveling around to brief various people and to fine-tune the traverses, so that everybody totally had input on them. But we sort of tended to be the ones that, like, kept them all together and kept track of the [changes] and presented them to people.

WRIGHT: You say lots of time. That's lots of hours. But did you have a lot of days and months to get all these details accomplished between the time we started and the time the missions actually took place?

HEAD: One of the things about being a geologist is that you have a very bizarre perception of time. It's a very long perception of time in the sense that, you know, for me time doesn't kick in until millions of years. So I have to calculate my own age. Like, I know my birth date, so that helps. But I couldn't tell you right now what year each of the missions flew in, or how long or what was going on. It's just, I'm not locked into the time scale like that, which is probably why I was able to help do this, because if you think back now, it's just unimaginable that all could be done in that short period of time.

But it was the group of people that were together, and I think one of the things for me was that—you know, you always hear these stories. I'm sure you've heard these. You've got tons of tape on this, but, oh, this wasn't any individual, it was a group of individuals, and dah-dah-dah had a team. Those sounded a little weird, the words, like, okay, yes, it's the party line. But that was so true, even with all these little difficulties that I was talking about. Everybody knew what the goal was.

So if you had a meeting, and I could only remember just a couple of times when any kind of interpersonal rivalry emerged in any of these meetings. And when it did, it was like you'd pooped in the punch bowl or something. It was, like, everything stopped, everybody, you know, "We're going to the Moon next week. I mean, come on, can't you guys do this somewhere else?" And it was incredible. So for me it was a real demonstration that if you agree upon a goal, people can really work together to get it to happen. That was just totally impressive to me.

Again, it's a little bit of retrospect, because at the time that's the way it is. But to have that be the way it is, is just no mean task. To have all these people agree with that was pretty remarkable.

WRIGHT: Did you have new people come into the circle of the decision-makers, or did the people who began the cycle stay with it throughout?

HEAD: There were always new people. I worked under Sam [Samuel C.] Phillips, Rocco Petrone, I think there was another one in there somewhere, you know, as Director of the Apollo Program, maybe one other. I can't remember now. But Rocco was the one that was there most of the time. The crews would change every time, and there were new people coming in and mapping, and the principal investigator for the geology experiment, it went from Gordon Swann to Bill Muehlberger, things like that. But I wouldn't say it was a gross turnover. There was a lot of consistency from time to time. But, yes.

WRIGHT: And when you got ready to look at the specific sites, was there a specific protocol of how you decided to do that, or were lots of people able to suggest different ideas?

HEAD: Well, there were lots of different ideas suggested, and largely they came from the geological and geophysical community, and a significant number of them came from the U.S. Geological Survey. A significant number of them were also determined by the images that had acquired by the Lunar Orbiter spacecraft, and that targeting was done largely by scientists like Hal [Harold] Masursky and others from the U.S. Geological Survey. So what that means is that

they had five Lunar Orbiter spacecraft, automated orbiters, that acquired images for the Moon for site characterization, certification, and so on, and as they got more and more data, they were able to turn these to things other than yet another set of flat areas with which you could count craters on, and they began to look at advanced science sites.

So the selection of those advanced science sites was really going to determine your menu for future sites, and there were quite a number of them. But a lot of input went into those decisions early on from the geologists who worked on the targeting of that, which were those people, I think, like McCauley and Wilhelms and Hal Masursky and other people like that. Then a lot of it was determined by increasing confidence in being able to land in certain places.

So, for example, there was no question that the first landing site was going to be in a mare, and it's going to be in a flat area, that the issue is which flat area. They're not all the same in spite of what it looks like in some of the images. So then after that there was a constant push to actually increase the capabilities by getting out of that narrow zone, equatorial zone, of flat areas, basically. One of the smartest decision, I think, that was ever made, I think it was made by Bob [Robert R.] Gilruth, was to go to the Apollo 12 site, what became the Apollo 12 site, which was the Surveyor III landing site, because what that did was, it challenged them to land next to that old spacecraft. You probably are aware by now that Apollo 11 landed long big-time.

So the idea that you could land it on a pinpoint thing was not just part of the—it was, like, a challenge to do that. So they did, beautifully. Remember when Pete [Charles] Conrad [Jr.] flipped over, and he and Alan [L.] Bean could actually see the "snowman" that was the target landmark? We knew then just instantly that that was just like, my god, you know, that this was going to open up everything, because if they were confident in the landing, then we could go to the highlands. Of course, Apollo 13 was in a more rugged area, and 14 finally went there, and

then 15, I mean, jeez, they came over Hadley mountains looking up, and they had to pitch over and land over this side of the rille, and they landed very close to the landing site. The same with 17, it was a box canyon.

So increasing confidence on the part of the engineers was mapped out into more and more complex landing sites, which increased the science big-time. There was a parallel thing which you allude to later on in some of these questions, that the relationships between the scientist and the engineers and flight directors, due to a lot of very insightful opportunities that people had and took advantage of, that changed over time, big-time. The interaction increased, the understanding increased, and the science benefited immensely from that. So by Apollo 14, the engineers and flight directors were pushing to go to places that the more conservative engineers didn't want to do, and they won. That's why we went to Apollo 17.

WRIGHT: There was the push, also, because the program was going to be cancelled, and you only had a few more times to visit.

HEAD: Well, we certainly were trying to optimize the science, but if I was an engineer, I would always be hard over on crew safety because the thing's going to be over if anything bad happens, as it almost was with Apollo 13. At the same time throughout this period, missions are dropping off the other end like crazy. I worked on Apollo 21 and 22 doing lunar rover traverses. People think, what, what are you talking about? I mean, there was an Apollo 21 and 22 at one point. But they just kept dropping off the end. So I think probably there was some pressure there, but I don't think it gets to the level that engineers are going to risk something.

Where a scientist might say, "We've got to push for this. We just can't have the same thing again. It's not worth the money or effort," and they don't fully understand the constraints from the engineering point of view. I think that, not that anybody risked the crews in any case in any of these decisions, it's just that typically with engineering considerations, you don't know all that stuff. You've never landed there. You've never tried this.

So you make your estimate and then you add what we call now in mission planning, "reserves." So you're trying to budget a mission and you think the experiments going to cost $50 million to build, but you've never built one of these before. So you put in 25 percent reserve, so it becomes more than that. So, in the same way, engineers, they're making these estimates and they're saying, "Yes, I think that probably it'll work like this, but I'd better put in—," what they call a pad, which is just essentially their hedge against what they don't know.

So each engineer all the way along the line tends to be putting that in, and, of course, sometimes they're additive. The best people in the program were people who were, like, flight controllers and flight directors and broad-scale engineers who could see where the pads were adding up and say, "You're being too conservative there." Those are the people that, I think, helped us the most, who could really get an overview and say, "Look. Go back and try that again, because I think if you did this other thing, you can—," "Umm, okay." Those are the people that helped. So it wasn't really like, "We're going to land there hell or high water." It was much more like, "Look. That's your estimate. I'm looking at this as an overview. You've both added 10 percent. That's the same thing, so let's go back and see if we can do that," and they [made] the effort to do it.

The easiest thing is not to do that, to be safe. You say, "No, we can't land there. Just go to the other place," and it's a safe landing. You're a hero, you know? But these people

ultimately knew, based on our interactions, how important it was, and so they went to bat for you. It was really, really quite amazing.

WRIGHT: Of course, the crews played a very important part in this because of their training, and then you helped them be trained so that when they got to the Moon that they would be able to—and even they got to the Moon, they'd be able to recognize the areas that they needed to. Would you talk to us about the training and how you got the crews ready to go, and how their confidence built from one mission to the other?

HEAD: Yes, I think, initially in the early days, which I wasn't involved in, sort of pre-Apollo 10, you know, they would have group field trips. From what I've heard from the people who were there, both the astronauts and the trainers, people like Dale Jackson and Gene Shoemaker and others, there was zero interest from the astronauts' point of view, in fact, some downright derision. People just thought it was stupid. So that was, like, probably not the peak time of astronaut training, per se.

Of course, at that time it was obvious why, because most of these people were not scientists. They were test pilots, and they didn't want to get their feet dirty. They wanted to be the first to do, fill in the blank. That's the kind of people they were, and we are where we are now because of that.

But slowly people began to realize that, okay, if we're going to continue to do this, that we have to be able to figure out a way to optimize the mission. Because clearly any of those kinds of people also wanted to do the absolute best job of whatever the mission was. That's

another characteristic of the test pilot or whatever. So the fact that their roles changed, in a way, gave them new perspective on what success was going to be.

I can remember one time where we were just kind of hanging around drinking beer with some of the crews. It was, like, pretty early on. We were just thinking about it. This was somewhere between Apollo 12 and 13, I think, and on a field trip. It was, like, I was looking at the way these EVAs [Extravehicular Activities] are growing here in time. I was kind of kidding them, saying, "[You all are] going to have to learn a little geo lingo if you're going to be on the Moon for twenty-one hours." "Hmm, yeah, twenty-one hours. You know, how many times can you say, 'Wow, this is a fantastic view? We've got the flag up. What do we do now?'"

It sort of grew on them, too, that twenty-one hours, that's a lot of time. We don't want [to] look, like, stupid, being stupid here. So many of them actually were interested. But those that were more or less just test pilots also got the picture, you know what I mean. You can't ask for better students because they're extremely highly motivated people who are very bright and are going to do the job, period. You didn't have to worry about this, and, you know, if you get nervous about, you know, like, with, sometimes with students, you have to bring them along professionally as well as from a factual point of view, and you're sort of counseling them on how to give your first talk as much as you are about what's in the talk. That wasn't a problem here. [Laughing] These people knew how to get there and back. So it was really more to optimize the science, and they were great students. We would end up, some of them were more interested than others, but they all wanted to get the job done.

Dave [David R.] Scott, the Commander of Apollo 15, for example, was totally into exploration. He knew that this was going to be the first of a major stage, the J mission, and looking, extending the capability. He was totally dedicated to the analog with essentially a host

of previous missions, but really Captain [James] Cook's voyage mostly. The parallels of that with how government sponsors research, why Cook's voyages were done. They weren't just exploration voyages. There was a background of, like, presence in the Pacific and all these other things.

So he [Dave Scott] was amazing. He really wanted to optimize the geology, and he did put pressure on to do certain things. Like, that's the only mission that had the stand-up EVA, because he wanted when he first got there to go look out the hatch, open it up, look around, and describe the terrain, because that's what you tend to do as a geologist. So that was pretty amazing. He also had a tremendous interest in the historical aspects. We would spend a lot of time—I spent a lot of time working on background information about researching crater names and stuff like that and to optimize the kind of, like, historical comparisons and so on.

He took, I think, yes, he took a piece of Captain Cook's ship, I think, to the Moon and returned it to the museum, I think, in New Zealand or something like down there, anyway. So there was a lot of stuff like that.

So, let's see. Yes, the training went through a transition of going from the early days, which I wasn't involved in, when I understand it was a pain in the butt for the astronauts, as far as they were concerned, to ever increasing levels of interest on the one hand and just simply doing a job of being on the surface and learning what they needed to do to do that.

I have to say that the people who participated in the exploration of the Moon on the surface and in orbit were—we'd have been hard-pressed to just send all geologists to do that. [Harrison H.] Jack Schmitt carried a very important set of background information and questions and capabilities there, no question. But I don't think that derides at all or detracts from the role that the people who went played. It's just amazing.

WRIGHT: Do you recall what crew was the first that you worked with?

HEAD: Let's see. I think probably Apollo 11, yes, because most of the other field trips—yes.

The other thing was that there was a division at Bellcomm between the people who worked on the surface things and the people who worked on the orbital things, for obvious reasons. So Farouk El-Baz tended to do most of the orbital aspects of the training with the command module pilots, and I tended to do most of the geological aspects of the surface exploration. So it was just good division of labor. So he tended to work much more with the photography from orbit, which was Apollo 8, 10, and so on.

As soon as the surface—I can remember field trips with the Apollo 11 crew, and relatively late field trips in Arizona where we were practicing them getting out of craters if they got into trouble. There was a concern about them getting into craters and not being able to get out. So it wasn't so much geological training as actually real terrain training, basic geological things, but also having somebody go down into the crater they can't get out of and then having—they had kind of like a tether-like thing that they carried. I don't think they carried it past 12 because the problems kind of went away, I think. But, you know, testing on that, like, okay, throwing it over and bringing them back up and so on.

So it was a combination of real-time sort of engineering-type training, geo training and geology. Then it just more and more, more and more details, like, yes, tons of time practicing as the J mission. Well, I mean, practicing with mobile equipment transporter for the 13 crew and doing traverses on craters and fieldwork and stuff like that, with the 13 and 14 crew, and then

much more extensive training with the 15 crew. We'd go all over the place and do rover-like traverses.

We had a little back room in the tent, and we'd have radios, and somebody would make up a geological map based on aerial photographs and do a traverse, usually one of the USGS people. Then they would take that and go out in the field, and we'd be at mission control. They'd describe it as if it was they were on the Moon and we were in mission control. Then we'd do debriefings and do that a lot.

So it got to be more specific kind of training, not just geological training, but traverse training, as it got closer to the missions. But in the intermediate time we'd take the crews out, once they were named, to analog-type areas. There would be geological examples, not really traverse kinds of things, and then you could evolve to the traverse-type things in similar other types of terrain. Then finally for the latter part of the crew training, when they were at the Cape, we'd go down there.

God, I commuted from D.C. to the Cape practically when they were down there, because they would—actually, Dave Scott really started this tradition. They had their day full. But he felt that they weren't getting as much geology as they needed, particularly because of the fact that, of course, as you get closer to the mission, everybody's got to talk to you, and, of course, geology's kind of low on the list for a variety of reasons, mission success and so on.

So what he instituted was us coming in in the evening, which was really their time. So usually maybe two or three of us would go down there, usually the PI [principal investigator] of the geology experiment, the CapCom [Capsule Communicator], who would usually be there anyway, and Jack Sevier, and one or two other people. We'd talk about various geological topics, getting them ready to go. It'd be great because you'd come down in the afternoon, and

you'd have dinner with them at crew quarters, which is a real treat. I mean, the food was—I've never had pork chops like that before or after. I don't where the hell they got them, but just say the word "astronaut" next time you go to the store in Cocoa Beach and maybe that'll work, I don't know.

But it was just really fun sitting around because it was their free time, relaxed, and you feel a sense of trust, too, because, I mean, man, there's just—walls are being pounded down to try to get to them, and it was a real nice thing. So then after that, we'd adjourn to the briefing room next door and we'd spend an hour or two on the traverses and whatever the geology, and it was great fun.

WRIGHT: The field trips that you talked about, were you responsible for setting up all those aspects as well?

HEAD: No, I was really a participant in those, but a pretty active one. The U.S. Geological Survey people were commonly the ones, and the people at Johnson Space Center who were designated to be in charge of crew training at those times. So there would be the principal investigator of the field geology experiment, who would be Gordon Swann early on and Bill Muehlberger later—well, initially Gene Shoemaker, then Gordon Swann, then Bill Muehlberger. So between them and the people at Johnson Space Center, they had arranged for where are we going to go, and then they'd do all the logistical arrangements through their staffs, and then we'd just have a division of labor and go from there.

WRIGHT: And then when you got to the traverse and the service activities, were those areas that you also planned, did you plan those specifically?

HEAD: Yes, on the field trips, you mean?

WRIGHT: Yes.

HEAD: Yes, I ranged everywhere from being CapCom person in the tents to—we each took turns doing things, like keeping track of the traverse, all the kinds of activities that we would do in mission control during the actual missions themselves. So, yes, we'd trade those around, depending on what's going on.

WRIGHT: Did you have any input on who was the CapCom?

HEAD: No. No.

WRIGHT: That was selection totally by NASA?

HEAD: Yes. Probably by the head of the astronaut corps and maybe whoever was head of the ASPO or something. I think it was—I'm not sure, I don't actually know how it was done, but I—

WRIGHT: Just curious.

HEAD: Yes. No, somewhere in there. They were uniformly good. I mean, Joe [Joseph P.] Allen was fantastic on Apollo 15. I mean, he's such a great guy. He's easy-going anyway. But, yes, they were excellent.

WRIGHT: And it was their role in this as well, that they knew the geo terms.

HEAD: Right, absolutely. That was really essential, yes. So they went on most of the field trips, if not all of them, and also participated in a variety of other training sessions.

WRIGHT: At some point you trained, and you sent word. The management staff brought them down to, or encouraged them to come down to show them how you were working in the field and what use that was. Could you share with us how that happened, where you had some of these key individuals come down on the field trips?

HEAD: Well, I think—I'm not exactly sure who was the key person responsible for actually getting that to happen, but once it began to happen, it was clear that it was the right thing to do. I suspect that Gordon Swann was one of the people who was responsible for that. I know certainly Jack Sevier, who saw the wisdom in doing that and worked as hard as he could to make it happen. So I'm a little hazy on sort of like who actually—bingo—had this idea and really was the driving force. I suspect it was one of those two.

So what we did was encourage a lot of the flight directors and other managers to come participate in the field training so they could really get a sense of what geology was about and so

on. It was just a natural. Plus, Jack and I would go around, and we spent a lot of time making presentations to various people in these different arenas, the FCOD [Flight Crew Operations Directorate] and just all the way around. Whoever was interested, we would do that.

I know that it had helped somewhat, because here were people who were coming to you, to tell you about what was going on. We'd stay there forever, if they wanted to, to talk about these things, because we knew these were—well, we enjoyed it because we were excited about it, but also we knew that these people, if they didn't understand what was going on, it was going to be—nothing would be optimized, you know what I mean.

In a way, I think this is one of the benefits actually of Bellcomm, too, was that—I'm just thinking about this situation at Headquarters. I mean, Rocco Petrone would have a status meeting on the various missions. Again, I can't tell you exactly how often they were. It seemed like they were pretty often. Rocco was an amazing guy. I mean, he had a great attention for detail, and so I would commonly end up giving the briefing on the landing site selection, on the landing site and the traverses, what's the status, what's going on, what do they look like, etc. So when Rocco's there, everybody's there. So the whole staff's there, because the boss is there. That's the way it's supposed to be. So I would get up and give—whenever I'd brief Rocco, the first viewgraph I would put up would be one of the full Moon, because I knew that he'd been thinking between the last time and the time we got together.

Invariably he'd go, "Oh, hold it. Hold it a minute. Jim, I just had a question. You know, I was thinking about this." So it would be some science question or some curiosity question about the Moon. He's sitting in front, and I could look in the back and see all the engineers going, "Oh, god, [boring]. This is going to go on forever."

But he really set the pace there in asking these kinds of questions, and I think even if you were just enduring this, it was something that people kind of got into. "Oh, gee, if we went there, we could understand this," and so on, and it became something of an integrated view rather than just an engineering challenge. I think the same thing could be said for a lot of the flight directors who came out and saw what it was like and the kind of things you would like to learn and why a little extra time here was important or there and so on.

Many of the crew helped in this a lot. They could see that, again, if they were going to optimize their performance on the Moon, that they had to have these people on their side. So I can remember a number of times where the crew requested things from the surface that were granted, based on logic, based on their perception of what was going on on the Moon scientifically, not just reading the dials back in mission control.

On the other hand, I can remember times when the astronauts felt that they wouldn't get permission, so they went around things. You've probably heard about the famous "seat belt basalt," you know. Have you heard this story at all?

WRIGHT: I'd rather hear you—

HEAD: Well, it's just on Apollo 15 on one of the EVAs, we'd been very focused on explaining to the astronauts that the question of was there any gas in the rocks as they came up [from depth within the Moon]. They undergo decreasing pressure, so it's like opening a soda water bottle with gas starts to come out. It's really a big mystery as to what was driving these volcanic eruptions, because gas is a big component of that on the Earth.

So we kept telling them to be on special lookout for rocks with holes in them, because the gas, when the rocks cools and the gas is coming out, it'll be vesicular, which means it just has a lot of holes in it from the gas, and that would be—god, if they saw one of those to get it. It's sort of like the "Genesis Rock." If you see something that looks like that, that's going to be a gold mine.

So they're coming back from, I think, the first EVA. I forget which one, but they've been told that it's time because they've been out there this amount of time and you need to get back. So Dave Scott said, "Houston, we're having a problem with a seat belt. I'm just going to get off and adjust this thing." I was sitting watching the seismometer, and it "zzzzzz," stopped, and you can see it stop, and then it gets all [Head gestures], jump back on the thing, and they say, "Okay." Then it takes off. "Okay, we're on the way back. It's okay. Everything's fixed."

Well, it turned out what had happened was that Dave had been driving along. "Whoa! There it is! There's a rock with all these holes in it. They're not going to let us stop." So they did this seat belt thing [to convince Mission Control that they had to stop], and it worked. You know, it worked. I mean, that was pretty remarkable, because the rock was very important and just like the so-called Genesis rock, in understanding many aspects of lunar science. So there was something. They knew what to look for. They knew how important it was.

Probably if they'd said, "Hey, we've seen the vesicular rock that we've all been talking about. Can we stop and get it?" the answer probably still would have been no. But it worked, so, as an example of at least them knowing and also having an assessment of the system, too. They were on the surface. They probably had a little better idea of whether they could drive a little faster on the way back or something like that. And they also knew a lot about the pads.

WRIGHT: While we're talking about training and talking about discoveries, share with us your thoughts of being there and hearing as they find these and knowing that some of the knowledge that you have helped to acquire has helped them find these wonderful discoveries that we're still learning from today.

HEAD: Well, at the time it just seemed totally normal, you know, it was just like you were doing your job. So it was just a sense of shared excitement of exploration and discovery. It's hard to imagine that you could actually feel like you were on the Moon with them, but that's pretty much the way it was, because you shared with them a lot of these things, and they shared with you in real time what they were seeing. So there was just, at least for me, this collective sense of exploration. I didn't get a sense of instant gratification, like, "Oh, I mentioned that to them, and they saw it." It wasn't like that. It was just a complete collective sense of "We're doing the job here, we're getting this, and we've got to see what it looks like when they get back, and make sure we marked that bag," blah, blah, blah, blah, more than anything.

Yes, so it was totally adrenaline, because it was a limited time on the surface of the Moon. You just end up not knowing how long they were actually going to be there. You never knew when something was going to happen. The only thing you could be sure was that something was going to happen that you didn't plan on. So it was a total adrenaline rush, and there actually wasn't a lot of time for reflection of that kind, you know what I mean, in that sense. But it still was, again, part of that teamwork thing. It wasn't like "I did this." It was like "It's really working."

WRIGHT: Were you already processing that information on how to use it for the next mission?

HEAD: Well, even for the next EVA. That was the critical thing, because we would go, take that information, and say, "How do we want to change it? Do we want to change the next EVA?" So we were constantly, yes, real-time processing it, the whole time, the whole time. Then for the next mission.

WRIGHT: And did you make a lot of changes in subsequent EVAs based on information?

HEAD: Some, yes, some. Mostly individual things, not in major changes except for technical aspects required at, like, problems with consumables or going back and having the drill not come out at Apollo [15], stuff like that where you had to take up the extra time to get that highest priority objective. But, yes, there were a lot of real-time calls.

Apollo 15, for example, again we landed forty-meter resolution data. So the question is, how many rocks were there? We wanted to go to the Apennine front, and we had this kind of, like, extended area along the base of the Apennine front where they were going to traverse. But when he [Scott] did his stand-up EVA, it didn't look like there were a lot of boulders down there, so the idea was to go all the way along there and sample these boulders. The radar data had suggested that there were a lot of boulders there. But when they got there, there weren't.

So, I remember this really distinctly, as the discussion. "Okay, what are we going to do here? Do we go all the way along there, or do we spend time where we are now to optimize what we're looking at? There are some boulders here, but we don't see many down there." So the decision was to really focus on what you're seeing, what you've got here. And that's where they found the green glass, actually. So those kind of calls were made, definitely.

Yes, there were things like—on Apollo 17, there was a gravimeter measurement made at the edge of the southern mountain range there, the South Massif. Its value was so different between what was taken around the lunar module and there, that they really wanted to try get one in between. So, the call was, okay, change the traverse, that you stop on the way back to deploy and get a gravimeter measurement. That's one I remember distinctly because it's so clear. You need to establish the gradient. Is it linear? Does it fall off or whatever? It's also one we did in one of the simulations. That's one I introduced. I introduced some readings which would force you to have to make that decision. So I put them in to force the people in the back room to make a decision, because it's so obvious something was going on with those readings. And that's essentially what happened. So it was good because we practiced it, and it was more like, "Oh, yes. Gee, okay, yes, yes, we can. That's important."

The other thing is that there was a lot of, like, in change. I mean, the way the thing was set up was good in that in the back room you had the field geology team and other people and so on and related people there, although, of course, they weren't in the mission control. They were in the mission control building, but not in the [MOCR] Mission Operations Control Room, I guess. So one person would communicate from this room to the CapCom—to the flight director, actually, to the flight, and that person was usually an astronaut. So, like, Jim [James A.] Lovell was the person on Apollo 15.

One interesting situation happened, which involved a question like you [are] saying about changes, had to do with this major issue about what we do down on the Apennine front. Okay, do we go all the way along the traverse or whatever? So we had this intense discussion about this, only the geologists. Jim Lovell's kind of, like, watching, like a tennis match, you know what I mean? Then finally the decision was to be, okay, we should stay here and optimize the

area around the thing. So everybody looks at Jim Lovell, and he said, "Wait a minute. Repeat that again."

Okay, so I said, "Okay, what we're seeing is this, this, this, and this. On the basis of that, we'd like to do this, this, and this, which means that we should stay pretty much where we are, okay?"

He looked at me and he goes, "Jim, take my badge, go down, and tell that to the flight director." Oh, shit. It was, like, "Uh…" You know, I'm thinking, you just don't stick your head in the door, and you don't say, "Hey, Jim Lovell sent me, you know." So it was, like, oh, my god, what am [I] going to do? Because I couldn't not do it, of course. But I couldn't, you know, I was really—.

So I looked around, and there was Schmitt standing there, okay, who was an astronaut, obviously, and he was scheduled to go in two missions. So I said, "Jack, come with me."

So actually I pushed him in the door, and then I came in and waved the thing [Lovell's badge]. It was, I think, Gerry [Gerald D.] Griffin, who I had gotten to know reasonably well. So he looks at me with his death-ray stare, like, "What are you doing in here?" you know what I mean? I kind of went, "You know, [Head demonstrates mumbling under his breath]," and I guess Lovell had mentioned, you know, and I could hear him going, "Oh, okay."

So, anyway, so he just said, "Go ahead," and he pointed to the CapCom. So I went up, sat there, explained it to the CapCom, who was Joe Allen. Then Joe looked up at the flight, of course, and got the nod, and it was sent up.

But it was like one of those things. It was, god, you know, it was a moment of truth for me. It was, like, jeez, you know. But, again, that was an example. Under more normal circumstances, it would have gone from the group consensus to Lovell to flight to CapCom. But

there were changes like that, and mostly some were due to science and others were due to essentially operations like problems, etc.

On Apollo 17, when it was clear that there was this gigantic boulder that had incredible diversity in it, and Jack almost could make his own call there, but we talked about that, and there was more time spent at there than, say, elsewhere and so on. So that was good. There were good updates.

Again, you're running totally on adrenaline on those things, too, because you know what the mission control area looks like. It's like, there are just no windows, so you can be in there for days and not know what's going on. [Laughs] Most people are, probably.

But I remember coming out on Apollo 15 at the end [of an EVA]. I guess probably it was the end of the first EVA. I can't remember exactly. But it was sort of like a break, and I came out with Deke [Donald K.] Slayton, who was the head of the astronaut corps at the time, and neither of us—we were just kind of talking. I just said, "That really went successfully," blah, blah, blah. We were both walking out the door. We were both going out of the door of Building 31, and it's pitch black. It's night. We'd kind of lost lock on the time.

We both looked up [to the sky] at the same time, "Jesus." It was the Moon, and it was, like, Deke was not the kind of a guy who emotes much at all, but it was, like, "My god, they're up there." It was incredible, just to be completely out of it, be totally focused on this, and then to walk [out] in[to] the night, and there it was. It was pretty remarkable.

WRIGHT: On the other side of that, before each mission there were a set of objectives that was clearly defined. What was the process for that? Who got the final call in making sure the objectives were in some type of priority?

HEAD: Well, let's see. There was a committee, as usual, that—I can't remember the exact name of it now, but essentially it was a science planning group of some kind that was responsible for approving the traverses and helping to get them organized. This is the one that Jack and I would constantly go to, back and forth and so on. It included people like Ray [Raymond G. Zedekar] from the time line group and so on.

A part of it, as I recollect, had to do with, again, making sure that the priorities between and among instruments and experiments was appropriate. So at some level, and, honestly, I don't remember exactly at what level, whether it was the Group for Lunar Exploration Planning or what, at some level there was a decision made about, okay, heat-flow experiment has the highest priority, field geology is next, and so on is next, something like that. Commonly they'd be broken down into elements, to deploy it, or do this or that or the other thing.

Then you'd argue about that, you know, about which had the highest priority and [what] the mission rules were. So there was a group of people who kept the mission rules, and that's where the priorities get mapped out into. It's like anything; you have a set of rules like that, like default things. If this problem arises, then the highest priority is you go back. You get the heat-flow probe and before you take off and do more geology-type things. And they just got argued out as a function of time.

WRIGHT: Did you have direct input into the priorities?

HEAD: Yes, that was part of some of the things that we did at Bellcomm in a systems engineering sense. So, yes, we certainly were involved.

In the final analysis, to address the question you asked me a little while ago, the Group for Lunar Exploration Planning and the USGS and JSC and Bellcomm, etc., all had input into this whole thing, but ultimately a set of recommendations were made for the site selection to the ASSB, the Apollo Site Selection Board, which was chaired by the Director of the Apollo Program and had representatives from the major centers and they made the final decision.

But, of course, like with any big decision like that, a tremendous amount of work had been done beforehand. So it wasn't like a university faculty meeting where everything is done from scratch. There was, like, a lot of background work. So it'd be really surprising if some dark-horse site came in at the last minute. It wasn't a rubber stamp, but a lot of work went into it beforehand, and they made the final decision.

So it was at that point, "That's going to be the site." I guess probably the NASA Administrator must have say after that, you know, for the final approval. I'm not exactly sure about that. Our big role was the ASSB, to get that finally through.

Then once that was done, then all the focus was on that site and the crew would be trained relative to that and so on. That represented change in crew training style as well, where you'd now go to something that was more explicitly related to that.

WRIGHT: What other components were part of your pre-flight analysis that you'd have to do?

HEAD: Well, mostly the Lunar Orbiter photographs were really important. The engineers did a whole host of analyses related to roughness, measurements based on crater frequency distribution and a lot of other things. There were, of course, a whole set of safety constraints that had to do with optimal—I don't know what, optimal—well, a whole set of mission constraints.

For example, you couldn't land over on the complete eastern side of the Moon because there was a mission rule that you had to have, I don't know, I don't remember exactly, but fifteen minutes between acquisition of signal and beginning of PDI, power descent initiation. So if they're out of contact till they come around the edges of the Moon, and if they need *x* amount of time in communication with Houston to make sure the orbit's updated correctly before they can start power descent initiation, and that means there's a portion of the part you can't land in over there.

So there were a lot of rules like that that constrained things. Initially the reason it was in the equatorial zone is that you didn't want to have the command module do a plane change, because then you'd have to get back to that point again. That's an added concern. So it wasn't until we were able to get them to agree to a plane change that we could go to sites like [Apollo] 15 and 17 and 16 and so on.

So there was a host of other things like that that operated. That's why it was so good to work with Jack Sevier, because he knew these cold, because he was an engineer. He had worked, like, Apollo 11 mission engineer. He'd pretty much been through the thing from alpha to omega, and knowing where you might be able to push on those was important, too.

I lost it there. Did you, was that—

WRIGHT: We were talking about the pre-flight analysis, the components of that.

HEAD: Yes, okay. So Lunar Orbiter images, and then sort of like engineering data for site characterization, the broad scale of mission constraints that told you where you even had access on the Moon, and there was emerging remote sensing data. It's hard to imagine this at the time, but we had almost no information on the chemistry of the surface before we landed, obviously.

But at the same time you could measure things remotely with a telescope, and that information started to come into play as spots began to be characterized on the surface and differences were seen.

Tom [Thomas B.] McCord, who was at MIT at the time, was key in that area, as were a number of his colleagues. So they were taking data, and we would use this to say, "Oh, you know, the Apollo 12 site is likely to be different from the Apollo 11 site because of these characteristics," and allowed us to distinguish between possible—we didn't have enough information about the Moon to know that it was going to be specifically this. We just knew that it was likely to be different, which was important at that time.

Then, of course, with each mission we'd get more information from orbital experiments. So there'd be images taken by the astronauts. On Apollo 14, for example, they took a special camera along to get pictures of the candidate Apollo 16 landing site, and so that kind of new data was brought in. Then with each J mission, like, there would be the [pan], mapping camera, very high-resolution images, which we immediately used to analyze the geology of the site and use that in traverse planning.

Here, for example, just compare this. You can see this is a picture of the Apollo 15 site, and this is a forty-meter-resolution [Lunar] Orbiter photograph. These are the names of the craters that the astronauts picked for frame of reference. But on 17, we had—I don't know where this is. Is this 17—no, this is 15. But the 17 site, you know, we had really high resolution, couple—few meter-resolution images, that we could actually pick boulders out that they could go it. So it was a very different situation.

WRIGHT: Camera equipment evolved as well, or did you have an opportunity to include additional equipment that you thought would help determine future sites?

HEAD: Yes, right. There was a high-con [phonetic] camera on Apollo 14, for example, that was very high-resolution, didn't perform as well as one would like, but, nonetheless, there was that opportunity, and also taking a 500-millimeter lens onboard to get really high resolution. We were able to take that onboard the Apollo 15 mission and keep it on for the next couple of missions, too. That mostly helped at the site. Like, they could stand on one edge of the rille and get really high-resolution pictures of the far edge. The pictures that you see of the mountains and the background there of Mount Hadley were taken, you know, it's fifteen kilometers away, but you could see the details of the structure.

WRIGHT: Were those photographs used in training the astronauts, or was it used just for your analysis?

HEAD: Oh, no, we used them in the training, totally, yes, always, yes. Then the traverse maps, the ones that they took with them to the Moon, were those maps with the traverses on top. So this is what they carried around on the surface, were these kind of, like, Mylar, stiff paper kind of—no, it's not Mylar, whatever it's called. I can't remember now, but anyway, stiff paper stuff [cronopaque].

Now, here's a good example here. We also had to do things like do walking traverses in case the rover didn't deploy, which it didn't initially on Apollo 15. So we had to work out a whole set of walking traverses, and they had all the things onboard to do that as well.

I guess another thing we did was—I'd forgotten about, too, is we'd work with the people in mission planning to do—the astronauts would have cuff checklists, as you probably are well aware. Each of those would be things not to forget to do or some just procedures on what to do. So we worked—I certainly worked with them on defining the key issues that are on those little things at each of the sites.

Once we got the traverses down, we'd work with them on the cuff checklists to put all the right things in and be sure that—yes, here are some examples here, just be sure that—here's stuff like investigate talus for the commander and lunar pilot, what you're supposed to be doing, a little bit about the kinds of trenches to dig, what to take, and so on. We'd also always put little surprises in there from place to place.

WRIGHT: Any special surprises you'd like to share with us?

HEAD: Most of them were a little joke kind of like things, you know, here and there. Most of them are so totally characteristic of the late sixties and early seventies, it's embarrassing to talk about them now. [Laughs]

WRIGHT: Any that you instigated?

HEAD: I was just an innocent bystander at the time, yes.

WRIGHT: Of course. Go on record to say that, right?

HEAD: Something like that, yes. No, it was interesting. Yes, if you go back and you look at the traverses in detail, you'll hear the seemingly unexplained chuckle from time to time. And that's what it would be. Basically it was a lot of guy stuff, if you get the drift. But anyway, it was a little tension-breaker perhaps. But it was, again, a good indication of the really good relationships among the crew and the crew training people, the people in, like, Ray Zedekar's group and so on. That was really quite good.

The crews always [had] a presence of mind that just, at the time, that was just normal, because you're all in this kind of together. They're working. They happened to be the ones on the Moon, and, yes, their butts are hanging out there a couple hundred [thousand] kilometers away. But they're just so astronaut that it doesn't—you don't even think of them being perturbed at all, okay. So it's really interesting to think about that. Like, we called Jack Schmitt up, I think, the night before launch in crew quarters. He was so hyper on the geology, we said, "Don't forget to enjoy the trip," you know what I mean. It was, like, it was just a lot of fun because the people were so tied up and things. But at the same time they would do things.

Like, for me personally, for the people that trained the Apollo 15 crew, the crew had made a decision to kind of name some things for these individuals. It was really amazing because I remember the last briefing we did was just, like, two nights before launch, I think. I forget now exactly, but the last couple of days they had by themselves to go out. There was all kinds of crazy things that go on, like tethered crab races in the astronaut quarter hallways, stuff that just, you know—nothing we tell you is going to help now, so just enjoy.

So … a number of people got worried [at the last minute] about, okay, when they land on the surface, how are we going to tell the major landmarks around? So I said, "Okay, I'll mention [it] to them." So this is when they were behind the screen at this point. They were in quarantine

by this point, so last briefing. So I said, "This is just one idea. If you're looking out when you look through the areas on the surface, remember that there's a big break looking due west, okay, and one looking due north, and one looking due south, and you've got the mountains at your back. If it's convenient, just call that one the west portal and the north portal and the south portal, just in your descriptions to us, we'll know what that's about."

They all looked at each other, "Yeah, sure, [Jim]. Good idea. No problem." It was, like, just this kind of, like, little bit of, like, maybe we pushed it too far here, because they go, "Yes, sure, yes. Like, come on, Jim, it's too late, yes." So I kind of, "God, I hope I didn't do anything wrong there."

Well, it turned out that they'd already decided to name these things after us. So when they were on the Moon, they were just kind of looking in different directions, and every once in while, they'd say, like, "Oh, there's Silver Spur." Of course, nobody had a clue what that was, and they'd named the south portal Head Valley, and when they said that, they were heading down and were looking at Head Valley, I missed it completely. It was like, "I don't know that area. What the hell was that?" Somebody said, "Did you hear that?"

So they even had the presence of mind to do stuff like that. It was just amazing. I'm not sure I could do that myself at all. But they really were quite remarkable people and incredible job to be able to balance all that, all the engineering, all the science, and in an incredibly hostile environment.

WRIGHT: Let's take a break right here. [Tape change]

HEAD: Yes, the question of being involved in the post-flight activities, we were involved in a couple of ways in the debriefings of the crews when they came back. This became increasingly important and increasingly personal as the missions went on and the group became really more focused and smaller in some ways. For example, Apollo 11 and 12 debriefings were a lot of people because, well, of course, it was a big deal, so everybody wanted to be there, but also everybody wanted to learn from it, too. So they were more formal kind of affairs that there were a hundred people there, something like that, maybe more. I can't remember now. But probably most of the real debriefing took place on a more personal level with the people who were key in the next mission.

But with time they became more personal in the sense that, I mean, I can remember participating—well, eventually what we'd end up doing, and I can't remember whether it was the formal debriefing or the informal debriefing, but we'd take all the tapes, the photos and stuff and go to some room in the basement of mission control and just sit there for a day and go through these things. That was just amazing, because for the first time you would see the astronauts responding to them seeing themselves on the Moon from the films, the TV cameras and things like that, which, of course, was totally different for them. So they could see themselves interacting, and, of course, they were pretty relaxed at this point, and it was hysterical. That was one of the funnest times, because we'd just sit back and go through it with a set of really good questions to try to optimize the next mission. But it'd just be a lot of fun, too. It was, like, they'd be calling each other klutzes when one kicked over this or that or something like that, and it was just a lot of fun.

So that was really important, because actually for us it gave a much better picture for what they really felt they were capable of doing and what was easy, what wasn't easy. Then we

could not necessarily write a bunch of memos, but really factor that into the next planning. So how long did it really take to turn those boulders over, or make samples here, document this, and then the other thing was a pain in the neck, or they were just doing their job, or what was easy and what wasn't. So that was great.

Then I was also involved in the preliminary examination of the samples in the Lunar Receiving Lab as a member of the preliminary examination team for a number of the missions. So you'd go there and you'd get in the glove box and the bunny suits and the glove boxes and just work with the basic description of the rocks, unwrapping the rocks. I helped in doing two that I definitely remember, were 15415, the Genesis rock, and doing the description of that, and also in unwrapping the orange soil.

Oh, my god, on the Apollo 17, which Jack and I, to a great media—you know, that was a big deal, because they were back and they were going to unwrap it. Well, of course, on the Moon, it really looked orange. I was standing next to Jack when he was undoing it. Of course, there are a bajillion lights as cameras and media and so on. You'd think that would have make it like the Moon. But for some reason, it just looked like dirty brown soil, and everybody's going, "Where's the orange? Where's the orange?" Well, it kind of looked like that at the time. But it was really spectacular. So those are the kind of things.

One of the reasons for doing that, of course, was then to factor into the next mission, thinking both from the sample point of view, which you were actually seeing and what kind of rocks they were able to really collect, and the job they did and actually packaging them and so on. Those were all really important in thinking about the next mission and understanding what we were actually finding out. So we were very closely involved. A number of us were at least closely involved in that as well.

WRIGHT: Were you involved in setting up the standards for the LRL?

HEAD: No, I had nothing to do with that. It was done well before I came along and by people who know that sort of stuff.

You asked a question about interacting with the simulations, the role in mission control during simulations. This was really interesting for me. There were a number of different kinds of simulations. There was the kind we did in the field where they'd be out there, they'd be doing their thing, and we'd be pretending like we were on the Moon. They were great.

But there were full-up simulations where all of mission control was simulating the mission. That early on introduced the problem of actually how you do that. So you couldn't early on do that from the remote site. You couldn't say, "Okay, we're going to be out in Arizona and hooked in with mission control," because there's an incredible communications mess. Eventually one was able to do that a little bit from time to time, for example, from the rock pile at the Cape, for example, where they were able to kind of, like, get in the suits, do their whole thing, and so on. But mostly earlier on it was just simply exercising the systems.

Actually even, I think, early on, you wouldn't even care that they were on the Moon. You would just say, "Okay, now we're going to do this. I'm going to set a time. It's going," and so on and so on. It's like there weren't even astronauts there. But it became pretty clear quickly that it would be important to run through the whole integrated thing, so what they needed was somebody who could actually pretend they were an astronaut.

I have no actual recollection of how I got in this position, but somehow I did, possibly because of the work that I did, you know, in the traverses and knowing them and possibly also

because I had hopefully by this time gotten the confidence of the astronauts and the mission control people working these different areas.

But what I would end up having to do would be to—we'd have a simulation. Okay, it's going to be August 12th. We're going to simulate EVA 1 of Apollo 15. So I would have to go to Houston and get together with the simulation supervisor. These people were incredible. They were the most feared people. So the sim sups, it's like they're God. So they're going to control what this thing's going to look [like]. They were actually a bunch of really good people. But they would say, "Okay, what we want to do here is we want to exercise a number of different kinds of systems," because I'm worried about this system, that system, maybe the suit or the rover or the whatever, whatever.

We'd get together beforehand, myself and a guy named Hiram [G.] Baxter, who was an [Philco] engineer down there, and we would be the two pretend astronauts. It was one of the most unbelievable experiences I've ever had, because you'd, first of all, be in on the whole thing. So the sim sup would, say, "We need to exercise this time these five systems. So you need to, Jim, figure out a way we can exercise those systems."

So, you know, I had to, for example, get a suit leak that wasn't terminal but was slow. So I had to think of a way in which, you know, I'd be going, like, "Oh, Houston, you know, I see this really interesting rock over here. It looks like a multiple breccia," something that would entertain the people in the back room and get them excited, the geology dudes, but at the same time rush over there, trip on the rocks, fall over, say, "Oh, I'm okay. No problem," and then drop my hand, and they'd introduce the suit leak. So it had to be something integrated that made sense. So I'd be going, "Oh, I see a really interesting block field coming over. I'm going to try to get near the crater," and then I'd pretend I'm driving towards the crater.

"Oh, it really looks neat. I can see these big boulders here, there, and everything." Then the wheel would fall off or something like that, and you'd do the wheel fall-off thing.

So we really worked together to pretend like you're on the Moon and make it something where the people in the science back room were being exercised, as well as then make it an integrated thing where the flight controllers and the whole flight operations setup would get realistic geologically, so to speak, realistic problems that would arise out of the surface operations, if you get the drift.

So that was a lot of fun. It was a lot of fun because you were sitting there at a console in which you had access to all the loops that the flight controller had. So you could introduce the suit leak, and you could push the button of the people in that part of the subdivision, the suit group, and listen to what—they were going, "Well, we don't see anything yet."

You'd go, "Oh, I think I'm stretching this a little bit," and they'd pump it up a little bit. So then they'd really get worried, and then you knew you were doing your job and stuff like that, and the same in the back room. You'd try to introduce things to the scientists that would make them want to change things. So you'd say something that was exciting geologically, but, like, you hadn't fully understood the implications of it. So I could sort of do that because I would know the implication of being a geologist, but an astronaut might describe something that they hadn't been trained for, but that might really be interesting. Then it would be up to the back [room], and then I'd punch in the back room, listen to them talking about "God, could that be a what's-it? You know, jeez, if it is, they ought to go back and look at that."

Then, you know, then when they were flagging from that a little bit, I'd say something like, "Actually it looks sparkly now."

"Oh, my god, that's it." So you really were able to try to optimize, really, the scientific return by introducing a number of things that made abnormal situations be normal in real operations, and that's an example. One of them I can remember is that gravimeter measurement, where we've done this before. That's, "Gee, you know, we know we want to do that," so they'd been through the whole thing, and it happened. But it was a lot of fun because it was total adrenaline, because you were punching these buttons and trying to listen in, watching the sim sup out of the corner of your eye. He's kind of, you know [an eagle]—and these were long EVAs. It was amazing.

Probably one of the best accolades I got in the Apollo Program personally was at the next mission review, which was the big review in Houston, was when the person who was in charge of all the simulation supervisors said, he was reporting, "We had this simulation and it really went well, and we want to give Jim Head an award for that. We're going to name him a half-astronaut," with the emphasis on the "half-as[s]," I think. But, anyway, I took it as a compliment, but, whatever.

So those things really had an effect, going through the whole thing. It meant that you really got to know all these people, too. So you could see that not me personally, but everybody, you know, back and forth, and they were really effective.

WRIGHT: Were you able to be in support room for every mission?

HEAD: Let's see. From probably 12 on, in the support or the support-support room, yes. Not for Apollo 11.

WRIGHT: Where were you for Apollo 11?

HEAD: I was home, basically. Yes, it was pretty amazing. Yes, because that was not a geology mission, per se. It was a really small group of people. It was just the core, total core there, and I hadn't been in the thing that long at that point. Actually, the success of that really was what caused things to blossom on Apollo 12. They carried geological maps, and in Apollo 13, there was much more training and a lot more, and on and on it went. It was great.

WRIGHT: How much difference does the rover make in achieving the accomplishments from the science area?

HEAD: Just orders of magnitude difference. You were traveling to a radius of seven kilometers. I have a plot, actually, that I made up which has all the traverses, including the Soviet Lunokhod traverses, all in the same scale. It just is incredible when you look at the difference between Apollo 11, 12, 14, and then the J missions, 15, 16, and 17. Just amazing. So you had to cover a lot more ground. You could see things in between. You could go to places you couldn't get to otherwise. So you could go to two or three or four different major objectives and successfully investigate them. Yes, it was just a very, very fundamental delta in this system from a science return point of view. Plus, you also had twenty-one hours of surface EVA, which is—that's a lot of time.

WRIGHT: The geological findings, did they meet up to your expectations, or did you have expectations?

HEAD: Well, it's sort of back to the "We're making this as we go along." I think so much was new that it would be hard for it not to meet your expectations. I mean, almost everything we were learning was new, and you didn't want to get complacent about that. There were people who would be satisfied with just landing at some point and picking up rocks. You have to appreciate that a significant number of the people who had worked on extraterrestrial rocks, they were meteorites, and nobody had a clue where they came from in context, geological context. They'd fall out of the sky, you know. So the idea of spending time to figure out exactly what—they'd done profitable analysis on those kinds of rocks for years. So they weren't so concerned about geological context. But the geologists really were, and probably went a little overboard on that, too.

There's a famous story, I think. Who was it? I think Neil [A.] Armstrong told me this, but Bob Gilruth kind of was watching the preparations for one of these traverses. The astronauts were supposed to document the rocks, take a stereo pair and a panorama and "before" and then take an "after." Well, that's a lot of time when you're picking up rocks. Bob Gilruth, being the kind of guy he was, you could see, he's going, like, "Hmm. You know, they're likely to come back with this big rock box with one little rock in it and a bunch of pictures, you know. That's not going to look very good."

So the word is that a couple of days before the thing, he said, "Neil, when you get up there, the end of that thing, take that shovel and fill up that rock box. Don't you come back with that thing half empty." You may remember that on Apollo 11, the indium seal of the thing didn't close. This is really distinct—well, because it's he's shoveling the stuff [into the box and getting

the seal dusty], which was absolutely the right thing to do, because you could spend all your time documenting these rocks and lose the sense that actually quantity is important here, too.

Sorry, I've lost lock on the point of the whole question there.

WRIGHT: We were talking about the expectations.

HEAD: I guess the only unrealized expectations were perhaps, some people would say, were some of the landing sites. Of course, having twenty-one missions, there were ideas about places that one would go to, like Marius Hills were a good one. A lot of the USGS people wanted to go there, because they had, like, morphological features that looked like volcanic deposits, cones, that were very similar to the ones in their home area in Flagstaff, and a lot of people were disappointed we couldn't go there, couldn't go to Tycho, which was a big impact crater in the southern highlands, or Copernicus central peaks, for example. That was on the list. It was ruled out for a couple of reasons, partly having to do with the fact that you wanted to go to multiple-objective sites where you could do multiple things because, in that sense, people knew the program was coming to an end so you wanted to optimized with the rover, being able to get to a bunch of different things that might, with smaller capability, like Apollo 14 or 12, you would have to go four different missions to go to.

But it would take a real cynic to say, "We blew it on that." Of course, you're talking to somebody who was involved, so I probably have not a completely independent view of it, and I certainly have a vested interest in it being a success as an individual. But I think given the capabilities and what we knew at the time, we learned an immense amount.

I think the best example of that is Apollo 16, where we went to a site which we thought we knew what was going on, we didn't know what was going on, we found out something completely different than we'd anticipated, and lunar science is the better for it, totally, you know what I mean, from that point on, because, in fact, it *wasn't* what we thought was there, and that's what exploration is all about. So, in that case, there's an example of something where one might be disappointed we didn't find what we were looking for, but they'd miss the whole point of what exploration was all about. Certainly would like to go more places, but I'm not disappointed.

WRIGHT: As you were unwrapping those rocks from Apollo 17, it was going to be the last samples from the Apollo Program, and your future was in front of you. Where were you planning to go, and how did everything that you had just encountered affect your next plan? Or did you know at that time what you were going to be doing next?

HEAD: Well, again, you're so busy doing that that, that, actually, a bizarre part of the whole thing was that starting—and again I can't remember exactly when, but maybe around Apollo 15, certainly by Apollo 16, Bellcomm was beginning to compress. You know, since it was known the number of total missions that were going to be flown, that had been decided, and we were praying that it wouldn't be less than that.

The range of people who were thinking the way to the Moon and back had done their job, in large part. So many of these people were [leaving], the size of Bellcomm was contracting immensely. I probably moved my office three times in the last two years, or one year, whatever it was, because, you know, smaller and smaller quarters. You'd go out on a trip, you'd come

back, and, "Had to move your stuff over the weekend," because it's a smaller group. But we were the ones who were doing the work at that time. The systems engineering had shifted to the traverses, not just the whole system of getting there and getting back.

So, jeez, by the end of Apollo 17, it was just a handful of people. So the handwriting was on the wall, absolutely. But from a scientific point of view, these were just data collections years. These weren't analysis years. These were making sure you did the job right to get the data. But then we would study to understand what actually was going on, and there was clearly years ahead of one in terms of those kinds of analyses.

We were just talking about that at the 33rd Lunar Planetary Science Conference, and we just had that. So the analysis has gone on for decades. For me personally, the people at Bell Labs were interested in helping me find a place to go, but I was so interested in what I was doing at that time, I wasn't really concerned about that.

Then Tim Mutch, who was here [at Brown] and who had since become even more involved in NASA after I left, put forth the proposal to come back to Brown, because he was starting to think about a planetary science program here. So I don't remember the exact timing there, but by the end of the Apollo Program, I guess I must have known that that's what I was going to do. I'd been made an offer and came here as an assistant professor of research. So, yes, there was a transition there, but you just weren't thinking about that. You had too much to do, you know, which is probably pretty naïve, but somehow it worked out.

WRIGHT: How are you still involved with NASA today?

HEAD: Well, since Apollo, I've worked on a lot of missions. I've gone on to be thinking about, well, of course, the analysis of the lunar data, which I still work on, and then continuing with comparative planetology. So Tim Mutch by this time had become principal investigator on the Viking Lander spacecraft, so I work with him a little bit on the Viking Lander data and interpretations during the mission operations and then went on to propose to and be on missions to Galileo, Magellan, Mars Global Surveyor. I'm on the Messenger [mission] to Mercury. So it's been a real kind of like ongoing analysis, just trying to understand the different planets and what they're telling us about the Earth. So we continue to do that, basically.

So I work with NASA a lot on these missions in a host of different ways, with experiments and so on, as do the students. Many of the students who have come through here are now at NASA Headquarters. Jim [James B.] Garvin, a student of mine and Tim's, is now the Mars Program scientist at NASA Headquarters. So these people are now in good positions of involvement in the program. A host of them are.

I still also work on astronaut training for the new classes of Shuttle astronauts, the AsCans [astronaut candidates], which is a lot of fun. It's been great to watch the evolution of the attitudes with the new people coming in over time. So every time there's an AsCan class, I'd go down and do a week of briefings or something like that on planetary science, and keep in touch with some selected group of them as they fly their Shuttle missions, too. So that goes on.

I'm also working with Europeans. I've worked for the Soviets a lot during the height of the Soviet space program, was an investigator on one of their missions, a guest investigator on two of them, actually, to the planets. We have a joint agreement between Brown and the two major space research institutes in the former Soviet Union. So we have a lot of people here, and the students get to go there. It's quite an experience culturally and politically and every which

other way, scientifically. So it's been a very important tool, because, obviously, the international aspects of the program are really important now, and it's important for the students to participate in that.

I guess an interesting aspect of that has been to get a perspective on the Soviet part of the space program, because I think when we were all in Apollo, we knew there was the political backdrop, and there was important reasons for doing what we were doing on a national, international basis. I certainly didn't have a clue as to what was going on and what the Soviets were really doing, and it didn't have any meaning for me, anyway. I just knew we had to do the best we possibly could, because that was the presidential mandate.

But, in retrospect, in getting to know these people over time, it's been really fascinating to meet the people who were doing parallel things on their side. Colleagues of mine, that I've known for years now, were working on the human exploration landing sites from the Soviet point of view and the Lunokhod missions and stuff like that. It's really fascinating. Someday we'll probably write that book, the comparative [aspect of the two programs].

One of the fun things for me was actually getting the Russians together with the U.S. astronauts. I remember a memorable dinner we had over at John [W.] Young's house a few years ago, where I took the Russians, two or three of the Russians who had been instrumental in the Lunokhod missions, and brought the maps and so on, and we had this incredible time where Johnny described what it was like to walk on the craters, and they described what it was like to drive on them. It was just amazing. I wish I'd taped it, but it wasn't the kind of thing you were going to tape; it was just a totally spontaneous kind of thing.

But the human exploration program has also been [of continuing interest]—we have here at Brown, Sergei Khrushchev, who is Nikita Khrushchev's son. I don't know whether you're aware of that or not. Yes, are you going to talk to him at all?

WRIGHT: No.

HEAD: Okay. He didn't have much to do with Apollo directly, but he's been just a very good friend and it's been incredible to get his take, because, as he said, he worked in [Vladimir] Chelomei's Design Bureau in the Soviet Union, which was one of the two major design bureaus for developing their program, the rockets, and the capabilities. As he says, "My father used to drag me to all these other meetings, like the Politburo meetings, where they were making these big decisions." So he's an incredible resource on what it was really like from their point of view. It's been just completely interesting to see that develop, to get better informed about that with time.

WRIGHT: Are you able to bring your experiences of your Apollo days into your classes, and, if so, what do you tell your students about the benefits of the Apollo Program, as far as not just geological studies, but as far as of the accomplishments involved?

HEAD: Sure. Yes, I definitely do that. I teach an introductory course in planetary geoscience called Earth, Moon, and Mars. It's a non-prerequisite general science course. So it's got everybody in there, from freshmen, clueless, to senior poets, or whatever.

So there's two things that we do, really. One of them is that, actually, I made up a lab, which takes lunar rocks and the thin sections cut from the rocks, where they actually take the actual Moon rocks and reconstruct in the lab the history of the Moon, which is, like, really, remarkable, that they're actually able to hold the rocks and say, "Okay, where does this come from?" in retrospect of what we learned when we were taking—what we didn't know when we were collecting, but we learned from that. Now it's just a freshman lab. So that's pretty interesting.

I also have a lot of stuff, like these traverse maps where they can actually see where the astronauts picked it up. I don't dwell on that too much, because that's a lot of the solar system to cover, but what I do try to do during the period of time when we cover the Moon is to get one of the astronauts to either come by or do a telecon, in which we take an hour, you know. I talk about five minutes at the beginning of that. "Okay, we're going to talk to Dave Scott. Here's the mission. He went to Apollo 15. Here's what it did, and here are some pictures," and then he'll get on there and talk about his experience, the science, and then there'll be half the period where they can ask him questions. So that kind of brings in the dimensions of exploration and the human aspects to it.

So what do I tell the students? I don't tell them much in the sense of justifying. We don't discuss a lot of automated versus human exploration. What I try to point out in the class in many different ways is that a lot of science accomplishments are done on a basis of events that have nothing to do with the science themselves and that you have to be both ready to optimize for the science when those happen and spot them coming when they do.

For example, we know the ocean floors on the Earth primarily because of what happened in World War II, where ships were going back and forth. You didn't know the topography, so

people had gravimeters and bathymeters on these ships so that they could tell where submarines might be and know the sea floor better. Well, you could never have done that and said, "Hey, we need a study of the sea floor. Let's send all these ships out." It would be years. So you needed to take advantage of that, know the data set was there, and then kind of take advantage of that to understand what's going on and to know what the best thing's to do for future study. So, in a way, World War II is responsible for us having a really important knowledge of the first-order character of the ocean and cracking the code on how the earth works.

Then subsequently, the cold war, we were mapping the hell out of the sea floor, and only part of that data comes available do we actually understand it a lot better, because people want to know where Soviet subs are going to be. So, giving them appreciation for the kind of interlinkage of history and science, and then the same way, Apollo. You could never justify going to the Moon and spending that money on the basis of the [science] results that humans could provide. You couldn't do it.

Like, you can't now justify sending humans to Mars on the basis of science. But you can, if it is a national imperative, clearly take advantage of the human's capabilities. What we got from the Apollo traverses would take us a long, long time of a whole host of automated missions to accomplish the same thing. There's no question about that at all, in complex instrument deployment, integrating things, seeing the green glass from where you were, recognizing that sparkling rock over there that you might not at all see from the rover, and just really Jack Schmitt going and working those big boulders over, because he knew what he was looking for and he could tell in an instant where the best sampling sites were and piece it together and document it. It would take you just an immense amount of time to do that with automated spacecraft.

We're getting to that point now, but if you had a choice and you had unlimited money, sending humans is the way to go. But, of course, we don't have unlimited money, so you take what you can get, which is very sophisticated remote-sensing kinds of things.

WRIGHT: You mentioned about how you lost track of what time it was, day-wise, night-wise. Every day was full, running to the next. Did you have any personal life at all during this time period? A day off to go fishing or go rock hunting, whatever you did for your hobby, did you have any of that during this time period, when the adrenaline was going?

HEAD: Well, it was pretty all-consuming. Being at NASA Headquarters meant you traveled a lot because you had to go, not just be at NASA Headquarters, but all these trips, and to Houston a lot, and the Cape and so on. I like to think I did, because obviously I had a family, and I tried to keep them informed of what I was doing on a general basis as well as we went to the Apollo 15 launch. We all went to Disneyland, stuff like that, at the same time, and they were able to see the launch. That was the one hiatus in there when we no longer were training the crews because the day before, that was it. Then you had a day or so before they got to the Moon.

But I don't know, you sort of made the time. I don't know. I have the sense that I spent a lot of the time at home with my two daughters, but probably not as much as I should have. I think there are a lot of casualties with personal lives in these kinds of, really, really focused kinds of things, and yet at the same time, I don't know.

I suffer from the fact, so to speak, that my vocation and avocation are pretty similar; that is, I'm totally curious about what's going on. So science isn't just like I come to work and do this. I mean, I'm always thinking about these kinds of things. So, if you're digging in the

garden or whatever, it's always kind of working about what's going on. So I don't get a sense of being a workaholic, although I put in an immense number of hours. It's not a pain, you know what I mean. It's just kind of a curiosity. I don't know.

That'd be a question you probably should ask my two daughters. But I do remember one thing where I would explain to them where I was going. "Okay, I'm going to Houston because we're going to the Moon." So I tried constantly to inform them about what was going on, so it wasn't just like I was gone.

I remember that the—probably Apollo 12, I kind of remember, anyway, this was, like, they're home watching it on TV. My wife and my two daughters are sitting there, and the first astronaut was there. "Who's that?"

"Oh, that's Pete Conrad."

The second one gets out. "Who's that?"

"Oh, that's, you know, Al Bean."

"Where's Dad?" [Laughs] So it was, like, one of these, "Wait a minute. He did all this stuff, and he didn't get to go?" [Laughs] It was great.

On the other hand, I do remember also coming home one time, and something I'm not very proud of, is I remember my youngest daughter going up to go to bed, and she was pretty young at the time, and crawling in my suitcase to go to sleep. It was not a good sign, you know. It was kind of symbolic there. So it's a big cost, I think, in some ways, but hopefully it all balances out.

WRIGHT: You got to do the simulations as an astronaut. Did you have any desires to be able to be one of the people that you planned to go up there?

HEAD: One of the things is that the astronauts were so good at making you feel a part of the exploration, that you felt like you were—I can't remember the term, but you're participating in it in a way that you sort of are there. There's a term for that. I can't remember exactly what it is. But you felt very much a part of what was going on. So that combined with the fact that you had your job to do and the fact that pretty much there was a set of people waiting in line meant that, sure, they call me up, I'd been at the Cape in a flash. But it wasn't like that was even remotely realistic.

Then people have asked me that about being a Shuttle astronaut, something like that. It sounds bizarre, but we have so much fun doing what we're doing in planetary exploration, that is, continuing on with this kind of, like, moving out and seeing these things for the first time, that although it would appeal to me, and once again, I would never turn it down, and if I had $20 million, I'd probably plop it down to go, but it's not something that I wanted to say, "Okay, now I'm going to go spend a significant amount of time trying to become an astronaut, to then wait a year or two, or at that time maybe three or four, to get a trip into Earth orbit."

It's, like, that would be great, but it's so much fun doing what we're doing in terms of continuing the lunar exploration to the planets and so on, that it wasn't something that was a priority. I mean, I'm totally curious. I'd love to do it. But exploration comes in many different ways and forms, and I think we're doing it in a big way here.

I remember one of the CapComs was saying to me one time, he said, "This is really silly for me to be going off to Ellington [Field, Houston, Texas] and you to be going off to the commercial thing. You should be coming with me, you know, to fly around to these different things."

I said, "You know, I kind of like that idea." [Laughs] He raised with, I forget who it was, Deke Slayton or somebody like that, and the only problem was I had to have, apparently, what I was told it was I had to have—what was it? I had to have, yes, survival training in Panama or something like that, you know what I mean. So it was off the radar screen at that time. But it was nice of them to think about that.

Yes, again, I think that that just the summary would be that they were so good at making you part of the thing that you just felt like you were part of the exploration, just tons of times, like inviting you into crew quarters when they were getting ready to go, and just a whole host of things like that in which you really felt involved, were pretty amazing.

WRIGHT: Looking back, do you feel like you have one area that brings to you that you would feel like your greatest accomplishment or your greatest contribution to the space program during the Apollo days?

HEAD: Really just participation. It gets back to that thing. It sounds like an old saw, but the team effort. I would say that, really, just being able to participate with a host of highly dedicated, focused people, who really knew how to do a job and get it done, learning from them, participating with them, that's about all you could ask. I think that was a privilege and an accomplishment at the same time, from my point of view, anyway. Everybody was doing their thing, but there's nothing I could think that would—just being part of it was really an accomplishment, for me, anyway.

WRIGHT: I want to just take a second here. If we could just pause for a second and give you a chance to think and to maybe review some of the information that you have. Is there anything else that you would like to talk about before we close for the day? [Tape recorder turned off.]

HEAD: —the rest of the night, too. Do you, I mean, is there anything else, or you're just looking at that particular aspect?

WRIGHT: Just that one right now. But we can certainly keep moving through here.

HEAD: Okay. Yes, just the issue of the volcanic history of the Moon, one of the key things, of course, was whether it had actually been molten or not. When the geologists looked at the images from the Lunar Orbiter, it was pretty clear that lava flows were the thing that was forming a lot of these areas in the mare. But other people were so convinced, particularly geochemists and cosmochemists. So it wasn't until the Apollo samples came back on Apollo 11 that people were then convinced that they were lava flows and they were volcanic eruptions. The age, the ancient age was a big surprise.

So it was clear at that point that these planets didn't just acrete cold, but that they heated up in the interior. That was a major change in our thinking, and we're still trying to sort out what that all means, what the heat source is. But from that point on, it was very clear. Then the data that we got from later missions, Apollo missions, lunar missions, the lunar sample return missions as well as remote-sensing data, subsequently from Galileo as it flew by the Moon a couple of times on its way to Jupiter, and also from the Lunar Prospector mission, and Clementine really showed us the diversity of mare rock types and the diversity of volcanic

activity on the Moon. So that's pretty much a done deal now. The question is how it actually happens, what the heat sources are, and what the early stages of formation of the Moon and its evolution mean about the later stages of volcanic eruptions. That's still a very exciting area of research, which a number of people are involved in.

Again, I think it's really safe to say that the Moon is just a keystone for the understanding of the other terrestrial planets. What we know about big impact basins, what we know about ejecta emplacement, what we know about melting and recognition of lava flows, emplacement of explosive eruptions in very different atmosphere environments, this is all very closely related to what we learned from the Moon. So that's been a major, major contribution to interpretation of the remote-sensing data that's been obtained from other planetary missions. Without that in-depth background that came from Apollo, we wouldn't be able to interpret these things very well at all, actually. Most people don't fully appreciate that, but having been through them all, you see the building and the assumptions that are going into the interpretations of a lot of these other planets.

Let's see. A couple of things about individuals in the Apollo Program. Indeed, if you think about it, I was really born at the right time. I can remember high school, when Sputnik went up. It's, again, one of those times that people who were alive at that time remember exactly where they were, because it's such a stunning event. It's a change in your reality.

It was very exciting at the time, threatening as well, because it was a Soviet spacecraft, and that was a big issue and problem for everyone. But on the other hand, I've come to since that time have the opportunity to toast my Soviet colleagues at dinners in their homes with vodka, thanking them for providing me with my education, because, in fact, my graduate

education was paid for by the National Defense Education Act, which was a total response to Sputnik. So they love the irony of that, you know. [Laughs]

Yet there have been a lot of people who were involved in this incredible endeavor, where they brought so many different things to the table in terms of getting to the Moon and back and understanding what was going on. Had I just gone through my normal education and gone off to some place, an oil company or a small university or whatever, I would never have been exposed to people other than sort of, like, local colleagues. But to be parachuted into this situation just by chance, because it just happened to be I got out of school when this was going on, was really amazing for me personally because I would just be working with cosmic-ray physicists, you know, planetary geophysicists. That was just becoming a field at the time. Engineers, managers, a host of people you'd never be involved with just in a normal sequence of events at that point in your career.

So that was just incredibly educating to me, to be able to work with these people, and then, most important, to see how it all came together. It wasn't just, "Okay, today we're going to talk to engineers and see what they have to [say]." It's everybody working together to make this goal a reality.

People that stand out are people like Jack Sevier, who was, again, part of the Apollo Spacecraft Program Office. He was just a very close colleague. You can design on paper a good collaboration in the sense that you take two résumés and you put them together, "Oh, these are very complementary. These people should be able to solve this problem." But, of course, the real clue is in the personalities. They can be hypergolic or not, in the sense of—you know what that means, right? Yes. Okay. So, hypergolic personalities are pretty common, particularly when they're complementary, because they're threatening to each other in some ways, you

know. But Jack and I, for some reason, really hit it off, and instead of being hypergolic, it was synergistic. We would both be able to ask each other so-called stupid questions, which led to each of us learning a lot.

So that's the kind of person I think you met in the program, and for the most part you just learned a lot. Of course, you had to do your job and you had to do it well. That's how you gained the respect that you could then build on to learn more. But there were hosts of people like that in the engineering side, Chet [Chester M.] Lee, in terms of management, and people like Rocco Petrone. Rocco was just amazing, very, very bright guy. Like I said, when we started these briefings, it'd be a good ten to fifteen minutes each time where he have all these science questions, and it was great fun. But tough guy, and you weren't going to get up there with any kind of BS either, that's for sure.

Jim [James A.] McDivitt, after his Apollo 9 mission, went on to become the head of the Apollo Spacecraft Program Office, and he was really, really excellent, too. He was a no-nonsense kind of guy. He had total common sense where common sense is really something that's not really so common. I always had a tremendous amount of respect for him in resolving things. When he would chair these mission reviews, you just knew the right questions were on the table and the right decision was going to be made.

One of the things that has always disturbed me is the fact that that rocket that you're looking at there that you all see every day, I guess, if you're at the Center, more or less, the one sitting out on the green, in the interest of JSC, should have gone to the Moon. I think that's the one that was Apollo 18. Jim McDivitt took me aside one night at a splash-down party and offered me the job of mission scientist for Apollo 18. Apollo 18 was going to be just going,

taking the command module and going into polar orbit and mapping things in a way that hadn't been done with the near-equatorial kinds of things.

Had I thought that mission was going to be a reality, that would have been an incredible thing to do, but my sense was that it wasn't going to be and that it would better for me to try to do this thing here at Brown, as I remember, at the time. But I would have loved working for him, because he is really, really a great guy.

Chris [Christopher C.] Kraft [Jr.] was amazing, too. He, again, a no bullshit guy who told it like it was, and pretty much turned out to be that's pretty much the way it was. That cut through a lot of stuff, you know, when you didn't have to—you'd just say, "Hey, we don't have time for this. You know, black is black, and white is white. That's black. That's white. Get back to me if it's not." You know what I mean?

Usually he had the right call on those things and is, to me, a really excellent leader. Same with a whole host of people in the Flight Control Division, Operations Divisions, etc. The flight directors, Gene [Eugene F.] Kranz, obviously, and Gerry Griffin and that crew, were just great. They really looked at and had an overview of what was going on such that they were flexible sufficiently to take input where it was coming from unusual places or just really see the overview and the evolution of the program.

We had, I think, in the waning days of Apollo, it must been after Apollo 17—yes, it was—we had a dinner, a science-engineer dinner somewhere over there, somewhere at JSC. It was pretty amazing to think about how it had come from real competition early on to kind of a celebration of good synergism. That was pretty powerful stuff, because it really did work that way. Yes, those were lots of people, lots of people, who were really just great, and all throughout the program.

I was kind of running out of names there and things. Let's see. What else do we have on this list here?

WRIGHT: Did you want to share anything with us about the time that you spent with the Lunar Science Institute?

HEAD: Oh, yes, sure. Yes, let's see. After I came here to Brown, I guess it wasn't very long after I came here to Brown, I was asked to be on the Advisory Committee for the Lunar Science Institute, it was at the time. So I agreed to do that since I was just a young professor, had hardly even gotten started. I was really pleased to be asked to be on that Advisory Committee. So I did, and very soon after that, the big guns on the Advisory Committee were not happy with the way the direction of the Institute was going in that they felt that it was going too far in the direction of things not related to the samples and the rocks and the results of Apollo, but to outer planets, satellites, and places that were more astronomical than geological or whatever.

I was, again, pretty naïve about all this. So there was in the background some dissension, significant dissension about the current director at the time, probably whose only crime was not doing what the Advisory Committee wanted and being offered another direction, but whatever. Anyway, they decided that it would be better to try to get someone in there who was more related to the basic program.

I was kind of a bystander in those decisions, having just come on the committee. But then, of course, once the director had decided to resign, so what do you do now? Then it became something that I was involved in, in a search for a director whose experience and orientation was

more along the lines of what it was felt that the community of the university sponsoring this was interested in.

I remember we were making the decision that, look, it's virtually impossible to actually have somebody come in at the present time. If we're going to get somebody good, it's going to take us at least six months to a year to actually to get them to agree to come. So it's not something that you're going to do overnight.

So the idea was posed by somebody, "Well, you know, we really need to get an interim director in to bridge the gap." Actually, I think it was Lee [Leon T.] Silver, actually, who was also there, said, "You know, I think we have somebody like that in the room now." I'm kind of looking around, and I said, "Jeez, I thought these guys all had permanent jobs." Then he was talking about me. So when it finally emerged who the hell he was talking about, I was in such a state of shock, I wasn't smart enough to say immediately no. [Laughter]

But it looked like an interesting thing to do, remembering that these were data-collection years in Apollo, the idea that you had at that time a lot of money, a million-dollar budget and a lot of staff, good staff, and the opportunity to bring in a whole host of people. The ship, in a broad sense, was, like, listing somewhat and not very oriented on a specific direction. So the idea that you could take a year to, actually, with some vision of what was done in Apollo and with emphasis there on potential future directions, try to set it on a right path, or at least maintain it so that somebody coming in could do it, was interesting.

It would not have ever have been anything I would have said, "I want to apply for that job." But posed as it was with a limited time and so on, it seemed interesting. So, actually, I ended up commuting to do this, because I also had commitments here [at Brown], and, obviously, as we were saying, it wasn't exactly the kind of thing that was conducive to family

unity. So, actually, I was able to work it out so that I commuted. I'd do one week down there and one week here. Then, also, I brought my family down from time to time, in certain periods of time. So that was kind of, like, a big deal for them. That was kind of fun. Houston in August, I mean, you know, "Whoa, Dad, it's great." [Laughs]

WRIGHT: It's an experience that—

HEAD: I remember my oldest daughter wearing shorts and not being able to sit down in the car. You know how it gets. What's the big deal, sort of. Then the snapping-turtle thing where you sit in the pool with just your nose sticking out. [Laughs] But, see, they learned something from it.

But at any rate, so that was quite an experience, and I did learn a lot in a very short period of time, because I was working here, too. I was trying to develop the program here. It was just amazing. I just learned a lot about the management aspects and development of staff and things like that. Again, it was total immersion, because this was not a position I'd had before and it wasn't a position I was moving into here at all either. But that was great.

So at the end of the time, that's all I wanted to do. I didn't want to be the permanent director. That wasn't why I took the job. It wasn't like, "Oh, this will be a nice step." I really wanted to be here teaching, working on research, etc. Yet at the same time, going through all that, it was terrific, because I just learned an immense amount. Of course, I interacted with a host of scientists, which helped me in the longer run, too, even more, because this is in a different environment. It wasn't just doing the traverse. It was, like, okay, what should the future of planetary science be, what should the future be here? So it was a great experience, but

it was not something that I had any aspirations to do permanently at all. I wanted to teach and do research. But it was really terrific.

It was before frequent flier miles, too. I don't know. I could have gone to the Moon, you know, [with all those miles].

WRIGHT: [Laughs] I imagine it's true.

HEAD: Right.

WRIGHT: As we get ready to close today, are there any final thoughts that you would like to add? The only other question, and I know you have answered this in roundabout ways, but I'm not quite sure if you would like to just close us out with, of the lessons that we learned from Apollo, what are you might feel might be the greatest lesson of all?

HEAD: Well, I would say that it's not a scientific one; it's a human one. It's that if you put your mind to it and have a goal that's articulated at the highest level and it's a goal that has imagination and substance, then it's amazing what people can do. Again, it's that old saw, but the reason you hear it so often is because it's so true. I don't think it affected anybody. It's made me realize how much humans are capable of doing when they work together, and it's also made me appreciate the failings of working together when goals aren't well articulated and agreed on.

So I think Apollo is a real tribute to human capability, to put individual differences aside and work towards a common goal. I constantly see that as a ray of hope in broader aspects. If

you just know that humans are capable of doing that, then you sort of have hope that in each of the individual areas, some collective group will get together and do that to further things.

I had to do the senior honors convocation, give the talk. Some faculty member gives a talk at graduation each year to the seniors who graduated with honors, and I got the [short] straw on that one this year. I was just going through and thinking about trying to give them some perspective on what's happened since this building was actually built in 1903, when the Wright brothers first—it was held out here on the green, and I was just trying to put in some historical perspective about where we are today. I kind of did the math. So, okay, this is, like, 1903. 1900, humans had not flown, and powered flight, and blah, blah, blah, blah, and 1957, the Sputnik. I think it was '57. I said, "A mere twelve years later, we were walking on the Moon, you know." Then I said, "No, wait a minute. That can't be right." [Laughs] When you think about that, it is just unbelievable.

I think if you put it in that perspective, it isn't because we had the technical power, because we didn't at the time. We had to invent that, and, again, I had to do the math on that a couple of times, actually go look up in the book to make sure that '57 was the right year, because twelve years, that's, like, nothing. It's nothing. And Apollo didn't happen in that either. It was much less than that. So it's just pretty amazing that that all happened. So I hope that that lesson isn't lost, and I'd say that that's the major contribution of the program.

A second one which is also very important is expanding our experience beyond the Earth, so when we look back at this picture, the type that was taken by the Apollo 11 astronauts, and this is the icon of the environmental movement, which is another way of saying, it is something where you see the Earth in its full glory for the first time but also in its loneliness and you appreciate the tenuousness of this. By looking at the other planets as the astronauts first did and

we went out to these other planets, you really get a perspective on where we are and where we're not and a perspective on history, of our place there, and a better respect for what we have as humans and what we're actually doing to the environment. So that's another really critical thing.

It's, like, if you just look just a few hundred years ago, not many hundreds of years ago, Jesus, you know, we were the center of the universe. It's like the Earth is the center, and, of course, it's gotten worse ever since. Not only are we not the center, but we're not even close to the center. The better perspective we have, the better the reality check we have, and I think that's something that Apollo really started as they looked back initially, seeing this, describing it, taking the pictures, and then picking up the rest of the record from looking at the Moon, is probably the second legacy, to me, anyway.

I had an opportunity to read Chris Kraft's book a few months ago, which was really—of course, I knew him throughout the Apollo Program, but coming into it in '68 or whenever it was, almost all the background stuff was a done deal. All the Mercury and Gemini were—all the things to work out about what you do and so on, were just done. Reading his book was great because it filled in the foundation on which the pinnacle was built, which I only knew from kind of like empirical word of mouth, sort of little things here that people talked about. But that book was great in just seeing how all that happened. It was just amazing. Just amazing.

WRIGHT: Well, we've enjoyed learning from you today and listening to your experiences, and we certainly thank you for taking your time out of your schedule to do this for the Oral History Project at Johnson Space Center.

HEAD: Well, I appreciate it very much. I don't reminisce much, but you can see this must have been some huge exception here. [Laughs]

WRIGHT: Well, we're glad you did it for us. Thank you.

HEAD: Well, I think it's really important to do this. I appreciate it very much. I listen to some people come and talk about what happened in Apollo with them not knowing that I was involved. It's really interesting to listen to. You know, wow. And some of them may be right, because my experience is not necessarily the way it actually was. That is to say, I'm looking at it from a certain point of view, and there certainly were forces at work, like the larger political forces, about the competition with the Soviets that could have driven things that I had no idea about. But lots of times history is really rewritten, of course, in the context of current events, and so I think it's important to have a set of realities as perceived for this by the individuals who lived it.

I remember when I was a kid, the teacher asked me, I think it was like in sixth grade, which is better to read, a history written of an event a few years after it happened or fifty years after it happened. I thought that was a no-brainer. Oh, it's got to be, you know, the one that happened just a few years after it happened, and she said, "No, not necessarily, because those people are too emotionally involved in what happened." It was just, like, I couldn't believe that that was a credible answer at the time. But, of course, I thought about it, and, of course, I think this could have been about the War Between the States in the U.S. That might have been the topic, in which case, of course, emotions were high, and it took a little time to get perspective. But probably both are right.

So I'm happy that there's an archive to get the immediate return, too, as well as the longer-term perspective on the forces that were involved in the events.

WRIGHT: And we're happy to be part of it. So, thank you, again.

HEAD: Okay, thanks.

[End of Interview]