GERALD M. SMITH
(b. 1931)

INTERVIEWED BY
JUDITH R. GOODSTEIN

October 10, 1992

ARCHIVES
CALIFORNIA INSTITUTE OF TECHNOLOGY
Pasadena, California

Preface to the Keck Series Interviews

The interview of Gerald Smith (1992) was done as part of a series of 7 oral histories conducted by the Caltech Archives between 1991 and 1992 to document the early history and development of the W. M. Keck Observatory at Mauna Kea, Hawaii. They capture the observations and perspectives of administrators, astronomers, designers, and managers representing both Caltech and the University of California, who would jointly manage the project.

Thanks to the support of Howard B. Keck, in 1985 the W. M. Keck Foundation donated $70 million for what would become known as Keck I. Construction began in September 1985 to build a telescope equipped with a 10-meter mirror consisting of 36 hexagonal segments that would work together to form one single reflective surface. Using only 9 of the segments, first light occurred in November 1990. By 1991, a further Keck Foundation donation made it possible to begin construction of Keck II—also with a 10-meter segmented mirror—with first light occurring in October 1996.

Subject area

Electrical engineering, JPL, Keck Observatory

Abstract

An interview in October 1992 with Gerald M. Smith, project manager for the W. M. Keck Observatory's two 10-meter telescopes on Mauna Kea until his retirement in 1996.

He recalls his early interest in electrical engineering and his work, after graduating from USC (1963), at the Jet Propulsion Laboratory on vidicon cameras for the Ranger, Mariner, Viking, and Voyager missions. In 1976, he is recruited by Robert Kraemer to help build NASA's 3.1-meter telescope on Mauna Kea. Later becomes deputy project manager for IRAS (Infrared Astronomical Satellite) back at JPL, working under Kane Casani. After its successful launch (1983), he is recruited by Harold Ticho as project manager for the 10-meter telescope the University of California hoped to build on Mauna Kea. He recalls later involvement of Caltech and the Keck Foundation in funding the project.

Discusses telescope's design; Caltech/UC partnership; leadership of then Caltech provost Rochus E. Vogt and physics division chair Edward C. Stone; his conflicts with project scientist Jerry Nelson. Difficulties with Itek, the manufacturer of the segmented mirrors. Comments on current delays in instrument building.

He concludes the interview with recollections of his family's stay in Hawaii in 1941, at the time of Pearl Harbor.

Administrative information

Access

The interview is unrestricted.

Copyright

Preferred citation

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CALIFORNIA INSTITUTE OF TECHNOLOGY ARCHIVES

ORAL HISTORY PROJECT

INTERVIEW WITH GERALD M. SMITH

BY JUDITH R. GOODSTEIN

WAIMEA, HAWAII

http://resolver.caltech.edu/CaltechOH:OH_Smith_G

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Waimea, Hawaii **October 10, 1992**

Begin Tape 1, Side 1

GOODSTEIN: Well to begin with, I thought maybe you'd tell me some of the personal details of your life.

SMITH: Well, I'm sixty-one years old, married, and have four children. I was born in Idaho, raised in California. Went to school in the San Fernando Valley—junior high school and high school. Went to USC. Spent four years in the Air Force.

GOODSTEIN: At USC, what did you major in?

SMITH: Electrical engineering. Actually I went to USC after I got out of the Air Force. So I was, you might say, not a good student in high school. I was something of a juvenile delinquent [laughing] during those days, and so I actually didn't finish high school. I got to about the eleventh grade and decided I didn't want to go to school anymore; I started working. I eventually went to trade school in Los Angeles to study, actually, electricity—power plant operations; I thought I was interested in that. I got married when I was eighteen. That was during the [run-up to the] Korean War. It was a good likelihood that I was going to be drafted, so I joined the Air Force when I was nineteen. I spent four years in the Air Force, went through electronics school there, and became a radar technician in various places, including California and Kansas. Eventually I got to Korea, but after the fighting was over. I enjoyed working with electronics, and by the time I got through electronics school in the Air Force, I knew I wanted to go into electrical engineering. And so when I got out of the Air Force, I went to Los Angeles Valley College, a junior college in Van Nuys, near North Hollywood, and spent two

years correcting the mistakes of my youth. [Laughter] Making up for things I had forgotten in high school. And then I transferred to USC in electrical engineering, where I got my bachelor's degree and my master's degree in 1963. I was about twenty-five when I started college, and I worked all the way through school after getting out of the Air Force, so by the time I got out, I was thirty or so. I worked in electronics and engineering during the time I was in school. By the time I got out [of school], I was working for a small company in Glendale.

GOODSTEIN: What was the name of the company?

SMITH: Correlated Data Systems. It was started by a friend of a friend I had worked with in San Fernando. The reason they wanted me to come and work there was because they were working some contracts with JPL [Jet Propulsion Laboratory] and they needed people to help with those contracts. So actually my first job with this company was to go off and work at JPL.

GOODSTEIN: Had JPL already switched over from the Army and become a part of NASA?

SMITH: Yes, this was in 1962, so they were well into it. And so I never actually worked for this company at their place. I went up and worked for them at JPL, where I was working on the Ranger program, which was the lunar photography mission. After about a year and a half, JPL offered me a job and I took it. I've been working for JPL ever since. It's almost thirty years now.

GOODSTEIN: What kind of jobs did you do for JPL?

SMITH: The first program was the Ranger program. It was really exciting for a young engineer, because the principal investigators in that program were Harold Urey and Gerard Kuiper and then Gene [Eugene M.] Shoemaker, who was a young Caltech geologist at the time, and Ray [Raymond] Heacock who was a member of our review board here just recently. Ray was a section manager for JPL. I was involved in the

camera part of the mission, so I was working with those people pretty closely. It was pretty exciting to be working with Harold Urey and Gerard Kuiper.

GOODSTEIN: Did you actually have hands-on involvement? Did you build things?

SMITH: No. At that point RCA was building a camera system in Princeton. We were trying to understand how you use the cameras to take quantitative data. Up to that point, television cameras were really just pictures you look at. But we were trying to understand how to measure things with the cameras—we were doing a lot of analysis on the photometric properties of the moon and then trying to calibrate the cameras so that we could actually measure the light reflected from the moon. We were mostly doing that analysis and overseeing RCA to make sure we knew how the cameras worked and how to use them to take the data.

GOODSTEIN: Are these big cameras?

SMITH: No, these were small, vidicon television cameras. There were six cameras on the Ranger mission—two wide-angle cameras and some narrow-angle cameras. The idea was to take pictures during the last ten minutes before the vehicle impacted the moon. The photography started off quite a ways away with the wide-angle picture, where you saw the larger image. And as you got closer, the narrow-angle cameras would take the last picture just before you impacted. And those cameras would get resolution down to a few meters.

The very first mission I worked on was Ranger 6. It was launched in January 1964 and appeared to go quite well all the way to the moon. But in the last ten minutes, when we tried to turn the cameras on, they didn't come on. So there was this panic. The spacecraft was heading to the moon, and you knew there was nothing you could do. [Laughter] We sent the commands to turn on the cameras; they didn't come on. We sent them over and over and they didn't come on. And the spacecraft crashed into the moon without taking pictures. That was really traumatic.

GOODSTEIN: That was your first—

SMITH: That was my first space mission. This all happened late at night. We had gone outside to look at the moon just before the spacecraft got there—it was almost full and overhead. And then afterwards we all wanted to go get drunk someplace—wash away our sorrow—but it was too late. It was two o'clock in the morning, or something, so we just went home.

So that was kind of a bad introduction to the space program. But it taught all of us involved some lessons we never forgot. It turned out that when we went back and looked through the test data, there had been some indications of a potential failure that we had missed. We had rationalized that we understood them, but there were plenty of signs, when we went back and looked, that we should have caught earlier to define things better. Everyone who was involved learned that lesson. [Laughter] In later missions they were a lot more careful and thorough in evaluating test data and understanding problems.

GOODSTEIN: Were you all new to the space game at that point, including Harold Urey?

SMITH: Yes, yes. Even JPL was new to the space game at that point. JPL had flown some earlier Ranger missions—Rangers 1 through 5—all of which had some kind of problems. They were really engineering development missions, and all had failed in some way. They were learning exercises, but by the time we got to Ranger 6, we thought we knew all the lessons and really knew how to do it. So it was terribly disappointing when it didn't work. But then we went back and fixed the problems, and Rangers 7, 8, and 9 worked beautifully. We had live television coverage of them coming into the moon and it was on the front pages of all the papers. We had lots of interviews. That was, again, pretty heady stuff for a young engineer. Those were exciting days at JPL. I don't think anybody who's there now will understand what it was like in the sixties and early seventies—the missions they were flying then, and the excitement, and doing everything for the first time. It was really a tremendously exciting time.

GOODSTEIN: Who was the director of JPL at the time?

SMITH: Bill [William H.] Pickering was director all through that time. Then he left in, I think, 1975 or ’76. Then Bruce Murray came in and was there for five years. Then we went on and worked on Mariner missions. My role at JPL during that time was really in the imaging television area, when television cameras were like small telescopes. In fact, they have a lens on them and they have these sensors; they have almost all the components a telescope has. We built the television cameras for almost all the Mariner missions and for Viking and Voyager.

GOODSTEIN: When you say “we built them,” were they actually built on the site?

SMITH: Well, we built them—we did it two ways. We actually did some of the hardware work in our labs at JPL, and we did the design and fabricated the parts on some of the components. And then some of them were built with subcontractors; Electro-Optical Systems was one; Ball Aerospace was another. We gave them the basic design and they did the detail design and fabrication. Then they sent it back to us and we tested it and integrated it into the spacecraft. So we were responsible for them, but in some cases we didn’t actually do all the work. As time went on, JPL did less and less of the detailed work and more and more of the contract management.

But in the sixties and early seventies, we were doing a lot of the work directly in-house, in our own labs. And that was fun, too. As you get further away from that, your understanding of what’s going on gets weaker and weaker, too. That’s why JPL was so strong in those days: They had a lot of people who were actually involved in the hardware. They knew all the details and they understood how to fix problems quite readily.

So anyway, I got a background in instruments—primarily in television systems—and in learning how to use them. At that time, we were starting to think about how to use electronic sensors in astronomy, because we had developed technology at JPL that we thought was usable in astronomy, and none of the major observatories did that at that time—or at most, they used primitive electronic sensors.

GOODSTEIN: Did you know any astronomers at the time?

SMITH: Well, Gerard Kuiper was an astronomer. And it turned out that during the time when we were working with him, he was pioneering the development of the astronomy sites in Hawaii—in Haleakala and on Mauna Kea. I wasn't particularly concerned or interested in it at that point, but some of the people we worked with—for instance, Ewen Whitaker, who was one of Gerard Kuiper's assistants—were over here observing on Mauna Kea at the same time we were doing the Ranger missions. This was in 1965, and I didn't actually know anything about Mauna Kea until about eleven years later, when I came over here in 1976.

In 1976, or a little earlier than that, NASA had contracted with the University of Hawaii to build a 3.1-meter infrared telescope on Mauna Kea. They had built a 2.2-meter telescope earlier. They had started work on the 3-meter with the University of Hawaii, but they were having some problems with the management at the university. The mirror that they were making cracked, so NASA had an opportunity to reassess what they were doing. And one of the people at NASA headquarters who had been working with them in the planetary program, Bob [Robert S.] Kraemer—I bumped into him in the hallway at JPL one day—asked me if I had any interest in coming to Hawaii to help manage the telescope they were trying to build there. At that time, I had been at JPL a long time. Things were slowing down, and I was probably in a midlife crisis of some kind [Laughter]. I said, "Sure, I'd really like to go." So we worked out a visit over here to talk to John Jefferies, who's director of the Institute for Astronomy at the University of Hawaii. They had the contract from NASA to build the telescope, so he really had the responsibility. What NASA was actually trying to do was to have me come over and help him. I came over here and met with him, and we hit it off pretty well. So we worked out an arrangement where I came over to Hawaii at the beginning of 1976 to manage the NASA 3-meter telescope for the University of Hawaii.

GOODSTEIN: Did you take leave of absence from JPL?

SMITH: No, no. I stayed on the JPL payroll. NASA paid JPL, and JPL paid me. And I had a non-compensated appointment at the University of Hawaii so I could sign paperwork, purchase orders, and administrative paper there. This was so I could actually

manage the operation while still being a JPL employee. And that's what we did. We formed a small project office at the University of Hawaii and redesigned the telescope and the telescope building. And that was at the time, I thought, right up my alley. Because I know a little bit about optics, I know a lot about electronics. I didn't know anything about buildings and structures, but we had good people there. So we put together a little group of people within a few months and built the NASA 3-meter telescope. It took us about three-and-a-half years. We built it within the budget and everybody was delighted. It was a great experience for me. The family loved living in Hawaii. We enjoyed it very much.

GOODSTEIN: Where did you live when you came over here the first time?

SMITH: We lived in Honolulu, in a suburb, Hawaii Kai. And we commuted over here to the Big Island. In fact, on my first trip in 1976, I brought my skis with me. We had flown over the site so I knew there was snow up there. We skied that first trip over here.

GOODSTEIN: That was your first site visit here?

SMITH: Yes.

GOODSTEIN: How many telescopes were there at the time?

SMITH: There was the 2.2-meter, the University of Hawaii telescope. That was built in 1966 and '67. And there were two other telescopes under construction: the Canada-France-Hawaii telescope and the UKIRT, the United Kingdom Infrared Telescope. We started slightly behind them with the NASA telescope. So at the time there was just really one major telescope on Mauna Kea and three other telescopes were under construction, all at the same time.

It was fun. We had a great team. My wife and I enjoyed living in Hawaii. Observatories have a nice mix of new technology and existing technology, and that offers a pretty broad spectrum of things to do. So it was challenging and interesting. And after working in the space program and worrying about things like reliability and quality

insurance, and all the meetings, and the tremendous overhead that goes into a spacecraft program versus a ground program, it was kind of fun to get rid of all that stuff. You didn't have to worry if it worked the first time; you could fix it. And it turns out you can do things a lot cheaper. We didn't have to go through all the detailed procurement reviews and approvals. We could streamline much more and do things much faster. And that was fun, because we could do things that I thought would have cost three or four times more to do within the NASA system.

GOODSTEIN: How many people did you have working on this project?

SMITH: At the office in Honolulu we had, I think, about twelve people at the most; a pretty small team. And it was a relatively small project. It was about $10 million, and this was in 1976. So with today's dollar it would probably be about a $20- or $25-million project. Having a small group made it fun, too. We didn't have a lot of outside interference. We had the money. We were dependent only on our own resources and abilities to do it. And that's always a challenge, when you can succeed or fail by what you do instead of having to rely on what someone else does. That's a lot more fun.

GOODSTEIN: Was this your first time, other than working on the Ranger program, that you came in contact with lots of astronomers?

SMITH: Yes. Well, almost all of the planetary space projects involved astronomers, because astronomers were the investigators for all the camera systems on the space missions. So we actually met with and worked with a lot of astronomers during all three of the Mariner projects, but on planetary- and spacecraft-related matters, not on ground-based telescopes. But I knew a lot of the people in the community. For instance, Gerry Neugebauer [Millikan Professor of Physics, emeritus; d. 2014] was involved a little bit in this NASA project at the University of Hawaii. He was on the science team that was advising the project. I had known Gerry before that, but this was the first time I had actually worked with him closely.

GOODSTEIN: Where did you first meet Gerry Neugebauer?

SMITH: Gerry was involved in some of the other JPL missions. I used to see him in meetings and around the laboratory from time to time. We're about the same age—I think he's a year younger than I am. So we bumped elbows once in a while around JPL. But it was 1976 when we actually started working together. And it turned out we worked together on another project after that, on the IRAS [InfraRed Astronomical Satellite] project.

GOODSTEIN: How did you get involved in IRAS?

SMITH: Toward the end of building the NASA telescope here, I was starting to think about what new things were coming up. And at the time, there was a lot of discussion about really large telescopes, 25-meter optical telescopes. And there were studies going on at Kitt Peak National Observatory on these new-generation telescopes, as they called them. And they were sending out, I guess, quarterly reports on studies they were doing. I read those, and at the time I thought, "Gee, it would really be nice to build one of those telescopes here on Mauna Kea." Several times when we were driving up to the mountain, I and my construction manager and some of the other people would talk about what we were going to do, and we'd say, "Wouldn't it be nice if these projects were ready to go in a year or two, and we could build something like that over here?" But, of course, it didn't happen.

So I started thinking about going back to JPL. At that time, Gerry had become involved in the IRAS project, and so he was coming over here and talking to me, asking me what I was going to do when I went back to JPL. I said I really didn't know—I'd probably go over and talk to some of the people there. And he suggested that I get involved in IRAS. So I went back there and talked to the IRAS project manager, who at that time was Kane Casani. He wanted me to come and be his deputy on IRAS; they had lots of problems and needed some help. We talked about it, and I thought about it and decided to do that. So when I went back to California in 1979, I became the deputy project manager on the IRAS project. Another person who was involved, whom I worked with, was Fred Gillett, from Kitt Peak. It was almost like a natural step-on-back

into the space program, with IRAS. But I still had some interest in building the big telescope in Hawaii someday, so I kept that in mind. [Laughter]

GOODSTEIN: Had you picked out the piece of property also, the site?

SMITH: No. But we knew there were several good sites there.

IRAS was a traumatic program: It had serious technical problems, with big cost overruns, and there was a lot of friction between the science team and the project and other people.

GOODSTEIN: Were you involved in that friction, too?

SMITH: Yes. It was impossible not to be involved. Everybody was so frustrated; there was a lot of acrimony. Even in the meetings, it would come out that some of the science team didn't like what we were doing, and they would complain about it publicly. Even on the science team internally, there was a lot of dissension. And there were some strong personalities involved in that. So it was really, in many respects, not what I had expected when I went back. When I went back I thought, "Gee, here's a nice international project; I can travel to Europe, go to meetings in the Netherlands, in England. Sounds like a good project." But what actually happened was very stressful and difficult.

GOODSTEIN: Was it because of the personalities or just the technical scope of the project?

SMITH: Well, first of all, my role was quite different. In the Ranger project, I was at lower levels, the engineer of one of the instruments. In IRAS, I was the deputy manager. Then I became the project manager. So I had a different responsibility, which meant my role in dealing with people was different. It was different in the sense of my job, but also the acrimony was different. There was some dissension on the Ranger team—Harold Urey and Gerard Kuiper were always at odds about their theories, about how things happened on the moon. But on IRAS, the science team members all wanted us to do things differently from how we were doing them. It wasn't a question of what they were going to do with the telescope. It was, Were we building the right detectors? Did we

clean out the dewar right? Were we doing things right? And they could criticize almost everything we were doing and want us to do something different. Meanwhile, we were trying to get the thing finished—to get it launched and fly it. This went on for about three years. And eventually when we launched it [January 25, 1983—ed.], it was almost a relief to get it off the ground, because at least in some sense the friction would be over, the problems would be over. It turned out that it worked extremely well and was a tremendous success, almost to everyone's surprise, because after all that pain and strain almost everybody was pessimistic when we launched it.

GOODSTEIN: You too?

SMITH: I was a little pessimistic [laughing], but not nearly as much as some of the scientists. I wouldn't have launched it if I'd been that pessimistic. But we were all surprised at how well it worked, I think. And it worked beautifully. It did tremendous surveys—probably one of the major contributions in astronomy in this century. So that was, after the fact [laughing], a great project, but during the project it was extremely painful.

GOODSTEIN: And how many years did the project last?

SMITH: I was involved in it for four years, and during that time I did keep in contact with what was going on in ground-based astronomy. I was still interested in that, and I went to a couple of conferences; one in Tucson in 1981, which was a conference on large telescopes. It happened to be at a time when I was there visiting on IRAS business, and I went over to the conference and just sat in for a while. That's where I first met Jerry Nelson [Keck project scientist, 1985-2012; d. 2017]. He had actually called me on the phone sometime earlier and was interested in having me help him start the plan. He was leading the development effort at UC then, and asked me if I could help him cost-out the project and work with him on some of the planning. I think he was just asking me to help him informally—give him some advice. I talked to him at that conference in '81.

And then a little later—I'm not sure how much later it was now—I heard from Harold Ticho, who was leading the management group for the UC development project.

There was an Executive Management Committee that Harold Ticho was the chair of, which is a pretty high-powered UC committee. David Shirley was director of LBL [Lawrence Berkeley National Laboratory] at the time, and Harold was the head of his department at UCLA; and they had Robert Sinsheimer [UC Santa Cruz chancellor] and Roderic Park [UC Berkeley executive vice chancellor and provost] on the committee. So it was a pretty influential steering committee for a project like that.

So Harold Ticho eventually got in contact with me and asked me to help manage the project. I told him I couldn't do it at that time because I was right in the middle of IRAS. I told him that when IRAS was finished I would certainly be interested in pursuing that. Then he asked me if I would consult and give him some assistance while I was still on IRAS, and I did. I spent some time, basically during IRAS, helping him develop some budgets and schedules for the project. Then, at the end of that, after I got IRAS launched in early '83, Harold asked me to come to work full-time as project manager, and I agreed to do it. The development program was just about finished then—Jerry had been leading it, with the guidance of this Executive Management Committee. So I basically still worked for JPL. But we worked out a contract between Caltech and UC, where UC funded my salary through Caltech. I started working for UC as project manager on the 10-meter telescope. In the summer of 1983, I went to UC Santa Cruz, and I spent the summer there, basically, putting together a plan for doing the project: trying to organize how we would set it up, staff it, schedules, budgets, and all those things.

GOODSTEIN: Had the idea that it would go on Mauna Kea already come up?

SMITH: Oh, sure. I don't know when UC first started thinking about Mauna Kea, but I think it was pretty early on. Actually, at that point, they had carried on some negotiations with the University of Hawaii about a site, so they had a preliminary agreement with the university about putting the telescope on Mauna Kea. And, of course, that was interesting to me, too. If we had been going to Chile, I might not have been so excited about it, because I still had the memory of my previous pleasurable experiences on

Mauna Kea, and I was looking forward to coming back here and working on the big telescope here, too.

So this was 1983. We spent the summer up there. They were trying to raise money, of course, for the project. It still wasn't funded, and they had put in $4 million or $5 million in the development program. But UC did not want to fund the entire project, so they were looking for donors. I went to a few meetings during that time and talked to various people about contributing to the project, but nobody really stepped up until we got a phone call from a person related to the Hoffmans—the Max Hoffman family. I've forgotten Mrs. Hoffman's name now, but I think it was her brother who got in touch with Lick Observatory. There had been an article in the paper a few days earlier about efforts to raise money for the telescope. Her brother had called into Lick asking about that and indicating an interest that the Hoffman family had in putting money into a telescope. That was sort of the start of the negotiation with Mrs. Hoffman. I don't know if you've heard that story. You probably have. [Laughter]

GOODSTEIN: I've heard some it. Were you at all directly involved in anything?

SMITH: Only at the beginning, because I talked to him.

GOODSTEIN: You actually talked to the brother?

SMITH: Her brother, when he called in the first time, yes.

GOODSTEIN: Were you the person who took the call?

SMITH: Well, it came in and was referred to me, and I talked to him and told him that the proper person to talk to at that time was Gene Trefethen, who was the formal fund-raiser for UC. I'm not sure how it evolved after that. But eventually, of course, they did work out a deal, unfortunately after Mrs. Hoffman died, to transfer $36 million to UC. Of course, it all fell apart later on.

GOODSTEIN: Did you have a sense in the beginning about how much the telescope would cost that summer when you were up in Santa Cruz?

SMITH: Well, at that time, I think we were looking at around $70 million.

GOODSTEIN: Even with Mrs. Hoffman's gift, you knew it wasn't enough money.

SMITH: That's right, it wasn't enough.

GOODSTEIN: And everybody connected with the project knew they were looking at a $70-million project.

SMITH: Well, I think the numbers probably varied between $50 million and $70 million at that point, depending whether you included instruments and other things. At least everybody was very positive, because the fund-raising had been floundering up to that point and now here was a real live donor who had money and was interested. Unfortunately, the follow-up on the part of UC was not very good at that time, because David Gardner was just coming into office as president, and of course he had a lot of other priorities. And by the time the follow-up was actually done, Mrs. Hoffman was quite sick. It didn't get finally signed off before she died, and that caused all the problems.

GOODSTEIN: Were people on the telescope project pushing Gardner?

SMITH: No, I don't think so. I don't think anybody really had any contact with Gardner. But he took on the responsibility for the negotiations because—this is all third-hand, for me—his forte was fund-raising. He wanted to be the negotiator himself, instead of giving the responsibility to someone else. He felt that fund-raising was his strong suit, and he wanted to be the prime mover.

GOODSTEIN: The story might have come out very differently if he had been more aggressive.

SMITH: Yes, I think it would have been quite a different situation, because UC then might have got more than $36 million, if it had evolved that way. I think Caltech's role would have been quite different. When Caltech got involved, UC had basically no money except a sort of tainted set of money from the Hoffmans. And so Caltech's role would have been junior partner, at most. It didn't come out that way.

GOODSTEIN: When you were in Santa Cruz, did it ever occur to you that Caltech would be involved in this? Was there any discussion on the part of people?

SMITH: Yes, and I'd talked to people at Caltech a number of times. In fact, we arranged a meeting at Caltech where Jerry Nelson and I went down and made a presentation to Caltech astronomy staff. I don't remember the date now, but it was probably in 1983. We went down and tried to get them interested, because there was already an interest [at UC] in looking for partners at that point.

GOODSTEIN: So the two of you made the presentation.

SMITH: Right. And I think it was a very influential presentation, in the sense that Caltech got very interested. Caltech, of course, was starting to think about big telescopes, too, and looking at what the options were. And the fact that I was involved, that I was a JPL person, that I had some reasonable reputation as a manager, I think, were all very helpful in terms of the Caltech involvement.

GOODSTEIN: Do you remember who was at that meeting when you made the presentation?

SMITH: Ah, no. I think Gerry [Neugebauer] was there, and Bob [Robert B.] Leighton [Valentine Professor of Physics, emeritus; d. 1997]. I don't really remember the details. Eventually Caltech formed a little review group that consisted of Bob Leighton and, I think, one or two others, to make an assessment of the technology of the 10-meter telescope—the segmented telescope—to decide whether they thought it was really technically feasible. And then I think the conclusion was from Bob that it was. He went

through several reviews and did some thinking and analysis of his own. So they convinced themselves it was feasible. I think I helped convince them that we could actually build it. And Jerry, of course, is a great salesman on the technology. So all that, I think, was instrumental in getting Caltech involved. But nothing happened there for a while. In fact, before Caltech actually got involved, I was ready to drop out.

GOODSTEIN: Why?

SMITH: Well the Hoffman thing had fallen apart, basically, because it looked like after Mrs. Hoffman died, the lawyers were fighting over the money and they wanted it back. And there were no other donors around. This was around early 1984, so I'd been involved for about six months at that point, on a full-time basis, and I didn't really see a lot of hope that it was going to get going. I told Harold Ticho at our meeting here in Hawaii that I was going to leave, and he asked me to stay for a little while longer, which I did. And during that period, Howard Keck got interested and started talking with Caltech about making a contribution to the telescope, and I was interested when I found out about that, and Caltech asked me to stay on. I decided it looked more interesting at that point [laughing], and I decided to continue on.

GOODSTEIN: When was the first time you got wind that Howard Keck was involved?

SMITH: I don't know exactly. I think it was in early 1984. I'd have to go back and look at my notes, but I think it was probably the spring, summer of '84.

GOODSTEIN: When Howard Keck stepped into the picture and offered the money to Caltech, did you have any feeling of divided loyalty? That is, you were working for the UC group as project manager and here Caltech had become involved. Did that present any problems for you?

SMITH: Well, I was probably one of the few people who saw this as all good. I mean it was a win-win situation, from my point of view. I thought UC wasn't going to be able to raise the money and that the project wasn't going to go forward. And so when the Keck

Foundation and Caltech came in, I saw this as a real positive development, because I felt that the entry of Caltech would make it a much stronger operation. The funding was, of course, the key thing; having the money is all the difference. Actually, I saw it as a tremendous opportunity to build the telescope.

GOODSTEIN: Was there ever any discussion of Caltech trying to go it alone and cutting UC out?

SMITH: A little—there was a little bit. Not in the sense of "cutting UC out." I think there was some discussion about what to do if they couldn't work out a partnership. What if they just weren't compatible and they couldn't really make a reasonable deal? How much would it cost? Could Caltech do it on its own? There was some discussion and some thinking about that.

GOODSTEIN: Did they ask you to become involved in any of the figuring?

SMITH: Yes, I did some cost estimates for a Caltech-only project.

GOODSTEIN: Who asked you to do that?

SMITH: I'm not really sure I remember now. It was probably Robbie [Rochus E.] Vogt. But I don't remember for sure. He was sort of leading the Caltech contingent at that point.

GOODSTEIN: He was then provost.

SMITH: Yes. I don't remember specifically that he asked me to cost it out, but I think he did. It may have been Ed [Edward C.] Stone [then chairman of the Division of Physics, Mathematics, and Astronomy] even; I'm not sure. But one of the two had asked me to at least do some estimating as to what would happen if Caltech were to proceed alone. But my feeling at the time was that it was a contingency plan, in case we weren't really able to work out an agreement with UC. So we did some estimates, but I don't think there

was ever any real chance that they were going to go ahead with that; it was really just some contingency planning. But there was honestly a problem there; that is, the UC people had suddenly gone from being the owners of the telescope—this paper telescope—to being actually, in some sense, not even partners, because Caltech was putting up all the construction money. And the way the deal finally evolved, Caltech actually holds title to the property. So UC is basically a fifty-percent partner in the sense that they get CARA leases. The telescope is leased back to CARA [California Association for Research in Astronomy] for a year, and CARA splits the time between the two organizations. But Caltech technically owns the facility—I think that was a stipulation of the Keck Foundation. So, even though it's equal, there's still—well, UC went from this position of dominance to a position of inferior equality, you might say. And that was a tremendous blow to a lot of the UC people, because they saw this small group of astronomers from Caltech suddenly take a dominant position on a project that they had developed for several years. And that was a very understandable attitude, in that situation. From my viewpoint, though, I thought it was all positive, because I think it made the project feasible, whereas before, I'd given up on it. I said I was ready to leave; I thought the project was dead. So Caltech just breathed new life into it, as far as I was concerned.

GOODSTEIN: Did you ever find yourself being a mediator between the two groups of astronomers?

SMITH: No.

GOODSTEIN: Did they ever ask you to be?

SMITH: No. No. I'm sure I was always considered—certainly at least after the first part—to be more of a Caltech person than a UC person. Although that's never been much of a problem with most of the people—at least I don't think it was. There are probably a few people who see that as a problem. But in terms of the management, working with the CARA board, with Bill Frazer [academic vice president of UC], it's never been a problem. When we first started, he was the board chairman. He wanted me

to sit down with him every week for a little while to tell him what was going on, to give him a little more comfort in my management of the project, I think. I did that for a while. And pretty soon [those] meetings sort of died out and he was happy. So there was really no— Actually, the Caltech people didn't know me all that well, either. Although I'd been at JPL for a long time, I had not worked with Robbie Vogt before, nor with Ed Stone directly. Gerry knew me, but the other people at Caltech didn't know me very well. So I was a bit of an unknown quantity to Caltech at first, too.

Begin Tape 1, Side 2

GOODSTEIN: I wanted to ask you if this was your first time working with Vogt.

SMITH: Yes.

GOODSTEIN: What was the experience like?

SMITH: Well, I liked Robbie. He was very supportive of me. He was absolutely crucial, in the beginning, in getting the project going and setting up the organization the way it ended up.

GOODSTEIN: More crucial than the president of Caltech and the president of UC?

SMITH: Oh, yes. I think he was really the key guy on getting CARA started the way it got started. He was tremendously supportive of the project and my management project. At the beginning, there was, of course, a desire on the part of UC to somehow see the project divided into two pieces, a UC part and a Caltech part. In fact, Jerry Nelson at one point even came up with an organization chart that had two organizations, one reporting to him and one reporting to me. And UC, I think, saw that as a— They wanted to have their responsibility defined in some obvious way. But, of course, it would have been a disaster to try to run a project with two groups like that, and Robbie shot that down just out of hand. He was such a dominant person that he shot that down very quickly. And his support for me, I think, was what really made the organization function well.

GOODSTEIN: There is only one organization.

SMITH: Right, just one organization. Actually, technically Jerry reports to me in the organization; in fact, of course, he doesn't, but organizationally he does. And that was tremendously important, because without some single leader on this kind of project, it just doesn't work. It falls apart. And Robbie knew that. He'd been around JPL and the space program, and I think he understood how such a project should work. And he was very supportive of that. He was a very, very strong leader at the beginning, resolving issues when there was some kind of a dispute about how good performance should be, or how we should do certain things when we had to consider science versus cost. He was very strong in helping to arbitrate and decide those issues.

GOODSTEIN: So you saw him quite frequently in the beginning?

SMITH: Yes, I saw him quite often. And, in fact, for a long time we had weekly meetings, until he was removed from the provost's job [1987]. Ed Stone, and later on, Gerry, would join us. We would sit and kind of go over what the project problems were, what the issues were.

GOODSTEIN: How long would these meetings typically run?

SMITH: Probably an hour or something like that. We had those meetings regularly, and that was a good place for me to bring him [Vogt] up to speed on issues I needed support on—a good place for him to tell me what he thought ought to be done.

GOODSTEIN: In other words, it was a candid exchange?

SMITH: Yes. Well, you can't beat Robbie. [Laughter] There's only one way to talk to Robbie and that's candidly. He says what he thinks, and you have to do the same, or else he doesn't listen to you. So they were candid exchanges, and I think they were very useful. I saw him as a very positive factor in starting the CARA organization off, starting the project off. And actually, also at holding down the friction. His sort of authoritarian

rule reduced the opportunity for friction. If it had been somebody who was trying to be more evenhanded, I think there would have been a bigger division. He was just very forceful in knocking these things down. If someone like Bill Frazer had been running things, there probably would have been a dual character of some kind in the project that would have not been constructive.

GOODSTEIN: Were there people who tried to get it to change, who challenged Robbie?

SMITH: No. Not in public anyway. [Laughter] Not in public. Jerry Nelson would go on in some of the board meetings. He would argue some point against an item, and Robbie would mostly say, "Shut up. We don't want to hear that anymore." [Laughter]

GOODSTEIN: The points that Nelson would argue: Were they scientific, engineering, or management points?

SMITH: Well, Nelson will argue any point. [Laughter] But mostly scientific and engineering, performance-related, points. They were things that were within his charter as project scientist. But he would argue, sometimes, beyond the point where anybody wanted to listen anymore. When decisions started to be made, he wouldn't accept the decision. He just continued to argue after a consensus had been reached against him. And that's when he would get shut down.

GOODSTEIN: Is this essentially the tension you always find between scientists, who are concerned with the research aspect of the project, and the engineer who has to deliver a project on time?

SMITH: Yes, there's always some of that. There's probably been a little more than that in this case, because that's the generic thing. But Jerry was also sort of the leader of the development program, and I think he saw himself as— He wanted to be the leader of the project; he wanted to be the recognized leader. There's no question that he wanted that job.

GOODSTEIN: You mean he wanted your job?

SMITH: Yes, he wanted my job. He wanted me to work for him, sort of—I would do my job and he would handle all the decision stuff. He wanted to be, you might say, the director, as opposed to the project scientist—a director in the sense of having administrative or management people who reported to him. That's my impression of what he wanted. He wanted to be able to make all the decisions, and he resented having someone like me, who had the authority to make decisions. We had many, many run-ins about that, of course, over the years. We very seldom agreed—even less now than in the beginning—on certain things. We eventually worked out an arrangement, because he was never— The board has never overturned any decisions I've made. I know Jerry has disagreed with a lot of them, and I think he's gone back and argued against them. Not publicly in board meetings. But after the board has decided, I don't think he's ever gone back and tried to appeal—openly appeal—a decision.

GOODSTEIN: Typically, what would such a decision be about?

SMITH: Well, there were only a few cases that ever got to the point where I said, "We're going to do it this way" and Jerry said we should do it another way. That actually came out to the board. There were probably only a few things like that. One of them had to do with the optical polishing at Itek. There was a large test mirror that we had in the facilities—that's a flat mirror—but it's used as part of the test, and it's called the 82-inch flat. It was sort of a classic confrontation that went on for quite a while, where the quality of the mirror was affecting the test. It wasn't as good as we would have liked it to be. And it was a question of whether we should take the mirror down and refigure it or leave it the way it was. There was a judgment about the trade-off in schedule and cost versus performance that had to be made there. My decision was that we would leave the mirror in place and use it the way it was. Jerry objected to that strenuously and argued long and hard for many months and eventually lost that argument. That was an argument where he never would accept the decision, and he still doesn't accept it. He still thinks we did the wrong thing, now that we've made all the mirrors. [Laughter] It's all done,

and he still thinks we did the wrong thing. That was one issue where we actually got to the board, and the board said, "We're going to leave it the way it is."

GOODSTEIN: Both sides were presented to the board?

SMITH: Yeah. The board got involved in pretty gory detail, because there was such a big problem at the time in making mirrors. That was, of course, certainly our biggest crisis on the project: making the mirrors in the early days at Itek. Itek was just not learning how to make the mirrors well. So the board got pretty heavily involved, because the overruns were big; the scheduling was in real jeopardy. We had a couple of board meetings back at Itek. Howard Keck even went back there a couple of times. So there was a lot of involvement on the part of the board in that process, and they understood the issue pretty well.

GOODSTEIN: How deeply involved did you get with Itek over their schedule?

SMITH: Well, very deeply. We spent an awful lot of time at Itek. We talked with them. Eventually we had to change a couple of project managers there and go through a lot of exchanges with the management. So I was very deeply involved.

GOODSTEIN: Why weren't they more responsive to the project's needs?

SMITH: Well, I think there were several aspects. First of all, Itek is an aerospace contractor; they've been working for the government for a long time. They had the mindset that they knew how to do things better than the customers. And that's probably true working with a lot of their DOD [Department of Defense] customers. But here we had some pretty experienced, intelligent people who had been working with this for a long time. We knew more than Itek did in this area, and they weren't willing to accept that and learn readily from us. They kept trying to do it their own way. Their management, also, had been working for the DOD for a long time. And so their idea of a schedule was something they get from the customer and then ignore. And it worked. [Laughter] When they had meetings with customers, they'd show them the schedules,

then put them back in the drawer and not pay any attention to them. We were insisting that they make schedules and that they work to the schedules and that they have plans to do things. And they weren't used to doing things like that.

GOODSTEIN: They were used to cost overruns.

SMITH: Oh, yes. Huge cost overruns. And the Itek people we had working on the project were that way. Most of their managers were not managers per se—they're customer liaison people—and didn't actually understand the job they were managing. They would have local managers and engineers who kind of ran the job. They didn't have *one* person who understood the whole job, like the manager should. So we kept running into problems because of this. There wasn't anybody at Itek you could go to who understood everything that was going on here.

GOODSTEIN: You had no counterpart, in other words.

SMITH: No. Well, there was a person called the project manager, but in many cases he just didn't know what was going on. He was really what I would consider more of a liaison guy. And that's the sort of people they use when working for the Air Force. He had generated a way of doing business for the government that didn't work for us. We were trying to do some new things, and they just weren't flexible and adaptable.

GOODSTEIN: Who chose Itek? I mean, did you have a choice?

SMITH: Yes. Yes, we had a choice. Well, Itek was probably my choice as much as anyone's, I think.

GOODSTEIN: Why?

SMITH: We went through the normal evaluation process: We solicited bids, we evaluated proposals, and we had a scoring system on which we rated them. And Itek came out on top of the scoring system. And I think we felt—I felt, at least—that Itek was the best

qualified contractor. That turned out to be a mistake, but that's what I thought at the time. They're very expensive, too, so when you make a mistake on their abilities, you pay a high price, because the cost is so high there. But probably nobody knew how to do the job, really, I think. None of the other contractors were more expert or more knowledgeable about how to do it—but they may have been more flexible and responsive in doing it. So we probably could have done better with one of the other contractors, in terms of getting them to learn the job, than we did with Itek.

GOODSTEIN: Are they making the mirrors for the second telescope, too?

SMITH: Yes.

GOODSTEIN: Have they learned? Is it better?

SMITH: Oh, yes, they're making them quite quickly now. I think it's going quite well. So they learned. But again, I wouldn't want to go there and try to do something new again. [Laughter] I think we'd run into some of the same problems. But they now have learned how to do this, and they're doing it reasonably well.

GOODSTEIN: Did the project suffer when Robbie Vogt left office as provost?

SMITH: No, I don't think so. I think it was already solid and running along quite well. So I'd say there was almost no effect on the project when Robbie left. We missed him, in terms of his presence on the board, and I certainly missed talking with him on a weekly basis. But it really didn't have any negative effect on the project.

GOODSTEIN: Who took his place, as it were?

SMITH: Ed Stone. At least he filled in his place on the board. Ed had been on the board, but obviously when Robbie's there, he's the leader. [Laughter] So Ed really stepped up into that, and of course has done an excellent job. He's one of these people that just sort of moves in and does what you ask him to do.

GOODSTEIN: But he's a different personality from Robbie.

SMITH: Oh, yes, he's much different. Robbie dominates things a lot more than Ed does. Ed is the consensus builder, and he tries to work with reason and logic. But he's very firm, too, and at some point he cuts off irrelevant discussion. He lets it go longer, certainly, than Robbie would. But he does cut it off eventually and keeps things going. So he's a very good leader in that sense, too. Ed also stepped in in terms of the weekly meetings. I started having those with him, instead of with Robbie, at that point. And we've had those all through the project, virtually; we've had a weekly discussion with Ed on problems, issues that I see, so he can keep informed on what's going on. And recently that's been expanded to include some of the UC people. They didn't know about it for a long time. [Laughter]

GOODSTEIN: Oh, they were not part of that!

SMITH: They were not part of that. It was— Caltech, I think, felt responsible for building the observatory. It was their money—Keck Foundation money—so I think they took a much stronger interest than UC did in seeing that the project went well. I think that was really the reason that it was a Caltech meeting instead of a UC meeting. Also, our offices were in Pasadena, so it was just much more convenient to work with Caltech people. I don't know if UC people had been on the Caltech campus, whether they would have been invited. Initially, the weekly meetings were intended to be like a small executive discussion. But they turned out to be a good forum for issues all the way through. But they did turn out to be Caltech-oriented issues, mostly, and nobody made a point of bringing it to the attention of UC—that we were having these weekly meetings—for a long time.

GOODSTEIN: And Jerry Nelson didn't know they were going on?

SMITH: No, I don't think so. Now we have an expanded version of this, which is a weekly teleconference that several UC people sit in on: Bill Frazer is in it and Sandy [Dr. Sandra] Faber is usually in it. Jerry still doesn't participate.

GOODSTEIN: Is that because of his differences with you?

SMITH: I don't know why UC has not invited him. My feeling is that I would prefer not to have him on. I mean, these are discussion sessions. I don't want to be in an argument all the time, or have someone argue with me about what I'm saying all the time. And that's sort of what happens with Jerry most of the time. At those sessions, he takes positions different from mine and it ends up in an argument.

GOODSTEIN: That's not the purpose of these conferences.

SMITH: Right. So I suspect that maybe the UC people sense that and have not invited him.

GOODSTEIN: I understand. That's how it is. He's not been invited to participate.

SMITH: Right. Nobody has ever asked me if he should be involved, one way or the other. In fact, I prefer the meetings very small. I think they're already now too big. There are about eight people. Well, it's a telecon, so we don't do it face to face. Maybe eight is too many. There's Ed Stone, Bill Frazer, Gerry Neugebauer, Sandy Faber, Wal [Wallace L. W.] Sargent [Bowen Professor of Astronomy, emeritus; d. 2012], myself, and Joe [Joseph S.] Miller.

GOODSTEIN: Joe Miller I've never heard of. Who is that?

SMITH: Joe Miller is the director of Lick [Observatory]. He's a board member.

GOODSTEIN: Sandy Faber?

SMITH: She's the Science Steering Committee co-chair—from UC [Santa Cruz]. And Wal Sargent is the Caltech co-chair. So Sandy, Joe, and Bill are UC.

GOODSTEIN: Are you the only engineer?

SMITH: Yes.

GOODSTEIN: Does that ever present any problems?

SMITH: Sure it does. I mean, I always had a different, more practical, perspective than they had—certainly a point of view more concerned with getting something done. I think typically the astronomers worry a lot more about how good the product is. And somehow there's a middle ground we end up on. But the emphasis always is, from my point of view, let's get it done. And do it good, of course. You don't want something that's not quality, but performance is not the ultimate from my point of view. It is from the astronomers' perspective—performance and quality. So somewhere in between, of course, you have to balance those out.

GOODSTEIN: So you deal with this on a weekly basis.

SMITH: Yes. Typically what happens in these weekly sessions is that I generate a set of notes: Sometimes it's status information, sometimes it's issues—it's a whole variety of things. I fax those out to everybody ahead of time, and that sort of sets the agenda for the meeting. I go through those notes, and usually somebody else has something they want to bring up and that gets tossed in. So it's really just a regular discussion session. It keeps them informed on what's going on now. It doesn't serve the purpose it did earlier, with Robbie and Ed and just the Caltech meeting. There it would sometimes focus on strategy issues as well. Now it's more on what's happening.

GOODSTEIN: The strategies—that was just because it was at an earlier stage?

SMITH: Well, those sessions were partly about how to handle the technical problems that we might see. There might have been other problems. And those problems were often, or at least sometimes, along institutional lines. In the case of mirror performance, for example, I felt it was always a bigger push on the part of UC to make it better and more

of a push on Caltech's side to get it made, at some reasonable quality. So I always felt probably more aligned with the Caltech people, because I thought they supported my position better. In some cases, though, when we're talking these issues, we're talking, "How good are we going to try to make these mirrors?" That would sometimes tend to be a strategy session. But if you're asking whether there was ever any overt UC/Caltech dissension in these meetings, there was almost never any. It was amazing to me that UC and Caltech were able to work together as well as they did. I didn't believe that they could when we started. I know there were problems that were outside of the board itself, but the board, I think, has always worked extremely well. Bill Frazer, Ed Stone, Robbie—they always worked extremely well together. I think it's been a tremendously successful relationship. The friction, the dissension, were sort of side shows to the main issue that they were able to work on so well together.

GOODSTEIN: Do you have any major problems now? I mean, by now it's obvious that the telescope is going, is a success. Are there any problems looming?

SMITH: No, nothing serious I would say. There's always issues: There's adaptive optics, there's new things.

GOODSTEIN: What do you mean by "adaptive optics"?

SMITH: "Adaptive optics" is a phrase for a technique to correct for atmospheric distortion to the images. A telescope's performance on the ground is limited by the atmosphere, which severely disrupts image quality. If you can measure these disruptions, you can correct for them. And that general technique is called adaptive optics. The military has been using it on Star Wars. They send laser beams out through the atmosphere without getting the light scattered too much. Actually, the military has pioneered a lot of this work. But now astronomy is getting interested in how to crack through the atmosphere, and we're getting involved in it too. We're developing a program now for a new set of techniques and technology that will be adaptive to the telescope. And it's a problem in the sense of figuring out who's going to do it, and how we're going to do it, and how it

interferes with the other work that we're doing. So that's one issue, you might say, that we're dealing with now.

I'd say there are no serious problems. As far as working relationships go, I think Jerry and I sort of have a truce that we work along with. He usually disagrees with me. Sometimes we tend to disagree because we don't like to agree, I think. [Laughter] There's some of that.

GOODSTEIN: He hired you as the project manager—back when?

SMITH: Jerry never hired me. Harold Ticho did. In fact, Harold Ticho wanted me to manage the development program that Jerry was running, and I refused. He [Ticho] was unhappy with the progress and management that was going on. The Executive Management Committee was running it for several months, and while I was consulting with them, they tried to drag me in to help manage it and I kept refusing [laughing], because I knew that would not work. But they clearly knew that Jerry did not have the ability to manage a project like this. So there was never any— Jerry was never in charge of the activity. He was sort of the technical coordinator of the development program, but the EMC actually ran the show with a pretty heavy hand.

GOODSTEIN: What happened to Harold Ticho?

SMITH: That's probably an interesting story I really don't know a lot about. But he moved to UC San Diego and became, I think, assistant chancellor there [vice chancellor for academic affairs—ed.] during this early phase, and when Caltech got involved he basically dropped out. I don't know exactly what happened, but when most of the Caltech involvement started to become apparent, within a few months Harold was out. I don't know if he dropped out voluntarily, or if the UC administration decided that they didn't want him in there. I don't know what exactly happened, but he undoubtedly feels some resentment. He was here for the dedication in November, and he was not a happy camper here. I think he felt—there was some resentment back there. I don't know what it evolves from, but he disappeared very quickly. The old EMC disappeared, and his involvement disappeared, and new people came in. Bill Frazer came in, and so did Ron

Brady, the UC financial person, and Bob [Robert P.] Kraft, who was the Lick director at the time, came in. Basically they came in as new members of the CARA board. And Harold Ticho was not to be heard from anymore. So I don't know what happened. But Harold was the person who brought me into the project. He's the one I talked to. He's the one who recruited me and persuaded me, actually, to come and manage the project.

GOODSTEIN: Did Robbie Vogt come to the dedication?

SMITH: No.

GOODSTEIN: Was he invited?

SMITH: I don't know. I'm not sure. I think he was. I'm pretty sure he was.

GOODSTEIN: I know that Jerry Nelson feels, sometimes, that this is his personal telescope. Do you ever get the same feeling?

SMITH: Yeah. Yeah. I don't— You can't feel that this is a personal thing. There's just too many people involved, too many people who contributed to it. And I have pride in it that we managed to build it. I think I've played a large role in it, because I basically put the organization together and did all the planning and supervised it all these years. So I think I played a major role. I'm not sure that somebody else could have done it. Jerry could not have built the telescope by himself. He's a tremendously valuable guy, a smart guy, but he doesn't know what his limitations are. Sometimes that's a big drawback too. You think you can do everything, and you can't. Nobody can. But [laughing] I know I have limitations.

GOODSTEIN: Do you think you know better what yours are?

SMITH: I hope so. [Laughter] I don't know. I hope that I don't stretch myself too far in those areas. But I know also what other people have done on this project, what contributions they've made, and I think I'm more cognizant of that than Jerry is.

GOODSTEIN: Who else has made a major contribution, perhaps people we haven't mentioned? Whom would you single out?

SMITH: I don't think I would single out a person. There are certainly another half-dozen or so people who are really important, who have played roles in making it go. If you asked who the person is that we couldn't have gotten along without, it would probably be Jerry Nelson. He's the one guy, I think, that we probably couldn't have gotten along without and made this go, at least in the early years.

GOODSTEIN: Is that because of the mirror design?

SMITH: Yes, because of the mirror design and the fact that it's been hard to find anybody else who really understands it very well. Jerry and Terry Mast [at LBL] were essential, from that point of view. I don't think we could have built this telescope—or gotten it started, at least—without them. Once we got started, we could have certainly finished without them, but they were absolutely crucial in the beginning. So Jerry's one guy you probably couldn't build this telescope without. I don't think there's anybody else in that category. But there are lots of people who made major contributions who aren't, in the creative sense, as important as Jerry—people who in the real, practical, sense are really important.

GOODSTEIN: When do you anticipate using the telescope? I know you had first light in 1990.

SMITH: We had first light in 1990, and we had the project review yesterday, and one of the comments was that in the last year, our operational date has slipped a year—our projected operational date.

GOODSTEIN: Were you aware of that?

SMITH: Yes, and it's partly because the schedule for completing the instruments has slipped. We're not building the instruments; they're being built at Caltech and UC, and the schedule has been delayed.

GOODSTEIN: Who's building them?

SMITH: At Caltech, Bev [John Beverley] Oke [professor of astronomy, emeritus; d. 2004] is responsible for a spectrometer, and Tom [B. Thomas] Soifer [Brown Professor of Physics, emeritus] and Keith Matthews [chief instrument scientist] are building the infrared camera.

GOODSTEIN: Bev Oke has just retired, and he's still building?

SMITH: Yes, he comes down to campus every two weeks and is still working on it. And at UC, there's a high-resolution spectrometer that's being built at Lick Observatory by Steve [Steven S.] Vogt, who's the principal investigator on that. And there's a long wavelength infrared camera [LWIRC] that's being built at the UC Berkeley Space Sciences Laboratory by Eric [J. F.] Arens. And there's a fifth instrument—a long wavelength spectrometer—that's being built at UC San Diego by Barbara Jones and Rick Puetter. So those are the five instruments.

GOODSTEIN: Do you have project responsibility over those instruments?

SMITH: No. We administer the funds, but that's all. Again, that's something I refused to take responsibility for, because I felt there was no way I could manage those instruments. The PIs are, I think, the best people to manage those. The Science Steering Committee has tried to help manage those instruments, too. I think they have their problems, but overall they've been fairly successful. But the instruments are late, and so the telescope staff is taking advantage of that by saying, "Well, they're not here and there's lots more things we can do." And we've been working on those things. But if they had been here, we would have probably put them on. We would manage to get them on. I would like to see the instruments, at least one of them, get here early, because it forces us to get ready.

GOODSTEIN: Any one in particular, or you'll take any instrument?

SMITH: Whichever is the first one likely to work. The one in the best condition at this point is the one I'd like to get. In fact, we're going over next week to look at the instruments and make an assessment.

GOODSTEIN: You're going to the mainland next week?

SMITH: Yes, we're going to Berkeley on Wednesday and Caltech on Thursday, and we'll try to make an assessment. We're looking at three of the instruments, and we'll review the status and decide what we think the likely delivery dates are. And then we'll base our schedule here somewhat on that. Our board would like to get some science going on the telescope—and I know Ed Stone would, because he's still trying to raise money from NASA to pay the difference between the Keck contribution on the second telescope and the total cost. NASA has sent in a letter of intent to participate, but they still need some real hard concrete evidence that the telescope is working; it's very helpful to them in getting funding from Congress. So there's some motivation, from a funding point of view, to get the telescope working quickly, as well as the fact that astronomers are quite anxious.

GOODSTEIN: These instruments, could they have been bought off the shelf?

SMITH: No, no. You could buy them from a contractor, but it would cost a lot more.

GOODSTEIN: So these are actually fabricated on university campuses, and scientists themselves make the designs.

SMITH: Yes.

GOODSTEIN: Is this normally the way it's done in astronomy?

SMITH: Yes, I think that's almost always the way it's done. The astronomers build their own instruments. In fact, a lot of people specialize in instrument building rather than doing the science. They almost become instrument builders rather than astronomers.

GOODSTEIN: Bev Oke is quite famous for being an instrument builder along those lines, I believe.

SMITH: Yes. Well, Keith Matthews is sort of that way, too. I'd say he's certainly more of an instrument builder than he is an astronomer in the infrared group at Caltech. There's a need for people like that, who are really creative and are interested in building instruments. It takes a lot of effort and time to build an instrument, so you have to have some motivation and interest there.

GOODSTEIN: The people who build the instruments, will they also use them?

SMITH: Yes, I think they will. But they'll also be facility instruments, so they'll be available to everyone from the two institutions. In some cases, the builders of the instruments might not turn out to be the main users—but I expect they'll use them.

GOODSTEIN: Once the instrument is built and installed, do you just leave it in place?

SMITH: Well, the instruments roll in and out of the telescope. The observatory has a modular system whereby we can take the instruments out and park them on platforms around the dome. So when they're not in use on the telescope, they are parked in those positions and then they're moved onto the telescope when they're being used. But they basically stay in the observatory, ready to go on the telescope.

GOODSTEIN: So you have these five instruments, and then it's a matter of who wants to use what instrument.

SMITH: Yes, it's a matter of scheduling. You schedule a time and then you arrange the instrument schedule to correspond to the astronomer who's going to be there observing.

GOODSTEIN: So, what you'd like is an instrument ready by the end of this year.

SMITH: Yes, that's what we'd like. That will force us to concentrate our attention and emphasize the things we really have to get done. There are so many things to work on. We almost need that kind of a forcing function to focus our effort on the most important things.

GOODSTEIN: You've never tested any of the instruments with the segmented mirrors.

SMITH: No. Well, we have cameras, so we've taken pictures.

GOODSTEIN: What do the pictures look like?

SMITH: They look fine. Well, if you've seen one picture of a star, you've seen them all. [Laughter] Except that sometimes you get excited about how small the dot is, instead of how big it is. We've done a lot of testing. We have cameras that we use to test the quality of the mirror—we've done that. You've seen pictures in the hallway here, our first-light pictures. We can take those kind of pictures. They're not typically scientifically exciting. We're basically doing engineering work, and we'll be continuing to do that until an instrument is here; then we'll be forced to focus on the instrument. So I think that would be good for us, because once we put on the instrument, that will cause us to use the telescope in a different, probably a more challenging, way. And we'll find other problems that we need to fix.

GOODSTEIN: Who is scheduled to be the first astronomer to use the Keck?

SMITH: We don't have a schedule yet. So whoever gets their instrument ready first I think is likely to be that person.

GOODSTEIN: Is there any competition along those lines—to be the first?

SMITH: I haven't seen anybody racing. I think they're all struggling right now. But there's a little bit: I think certainly the infrared camera at Caltech would like to be first.

GOODSTEIN: That's Keith Matthews and Tom Soifer?

SMITH: Yes. I think they would certainly like to get in there first, if they can. But the others don't seem to be in a real hurry. They have a lot of work to do, and they're trying to finish it off.

GOODSTEIN: And you don't know how the instruments will perform at 14,000 feet, either.

SMITH: Well, the altitude for the instruments is not really a concern. It's mostly just getting them onto the telescope and understanding how they work when they get real starlight—getting all the alignments and everything set up so that the image falls in the right place and learning how to get the data out and process it. You have to cool the instruments, carry the heat away; a lot of interfaces have to be connected up and tested and working.

GOODSTEIN: This is a different question altogether. How do you handle sewage and electricity and water up at 14,000 feet?

SMITH: About the same way you do anywhere else. There's a commercial power line that goes up the mountain now. Up to a couple years ago, we relied on a diesel generator. We still have an emergency generator if the power line goes down. So there's a commercial line that goes up to the summit to provide electricity. Water is trucked up by tanker, and we have a 4,000-gallon water tank on the summit that we fill about once a week. Sewage goes through a septic system, basically a cesspool. So it's pretty simple.

GOODSTEIN: Just the way it's handled down here in the country.

SMITH: Yes, it's about the same, except we don't truck our water in. We have a water distribution system here. If you're out south of Hilo, you use well water or catchment water or something like that.

GOODSTEIN: Can you use the melting snow as a backup for your water?

SMITH: No, not really. It's too hard to catch the water. There's no convenient place to get the runoff. There's a lake up there, but I don't think they would like us to take water out of the lake. [Laughter] It's a small lake.

GOODSTEIN: I didn't see it.

SMITH: It's part of the science preserve area. It's behind one of those cinder cones, so you can't see it from the road.

GOODSTEIN: Do you see the Keck as your last big project for JPL?

SMITH: I think so. I'm not sure what I'm going to be doing next, but I doubt that I will take on any other projects. I may do some consulting, maybe help with some other things, but I certainly don't expect to take on responsibility for another big project. I think this is probably my last.

GOODSTEIN: Would you come back to JPL, or is Hawaii home now?

SMITH: That remains to be seen. I don't think I'm going back to JPL—I'd say that's very unlikely, because I'm not really anxious to go back to Pasadena.

GOODSTEIN: Was the meeting in the seventies the first time you'd ever come to Hawaii?

SMITH: No, actually I was here in 1941.

GOODSTEIN: What were you doing here in '41?

SMITH: My father worked at Pearl Harbor.

GOODSTEIN: Is that so!

SMITH: Yes. I was raised in North Hollywood, where my father, who immigrated to California from Idaho as a young man, was working for Eastman Kodak. Then he decided to go into business for himself, so he went back to Idaho, to Sun Valley, and opened a gambling casino. So we all moved back there in 1940. Within a year or so he had gone bankrupt, and he needed a job. And at the time—this was in early 1941—there was a building boom at Pearl Harbor. They were advertising for construction workers and offering to pay their transportation to Hawaii. He was broke, so he signed on to go to Pearl Harbor to work. The family went and stayed with grandparents in Idaho. My father worked at Pearl Harbor, saved his money, and then a few months later, we came over to Honolulu in the middle of 1941, about six or seven months before Pearl Harbor was bombed. And so we lived there. We were there when Pearl Harbor was bombed; we were about seven miles from the harbor—a little town called Kalihi. And then as soon as it was feasible, we went back to California, in the middle of 1942. So that sort of gave me a feeling for Hawaii. I was nine years old or something. So I remembered it and enjoyed it. And when this other opportunity came up later on, I had a good feeling about Hawaii. I said, "Gee, I really liked it there. I'd love to go back." So it certainly gave me an inclination to come back here.

GOODSTEIN: Do you remember the bombing?

SMITH: A little bit. Not much. I remember the smoke and the airplanes flying around, and things like that. But not a lot of detail.

GOODSTEIN: Anyway, your whole family got out safely?

SMITH: Oh, yes. That time was exciting for a kid, a lot of action going on. We thought it was all great, but the older people didn't like it so well.

GOODSTEIN: Your life has come full circle.

SMITH: Yes, so we've ended up back here. I think being here in 1941 was a very strong factor in making me feel receptive about coming back in 1976. I don't think I would have considered it a second time, if I'd never been here—or even have thought about it.