ORAL HISTORY TRANSCRIPT

GEORGE E. MUELLER
INTERVIEWED BY SUMMER CHICK BERGEN
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BERGEN: Today is January 20, 1999. This is an oral history interview with Dr. George Mueller, in the offices of the Kistler [Aerospace] Corporation in Kirkland, Washington. The interviewer is Summer Chick Bergen, assisted by Carol Butler.

We thank you for allowing us to come up and talk with you again.

MUELLER: And it's always a pleasure to be with you ladies.

BERGEN: As I said, I'd like to follow up on some things we talked about last time, and I'd like to start with a couple of management questions. When you first came to NASA, some people said that the centers had a "state's rights" attitude regarding their relationship with headquarters. How would you describe the centers' attitudes when you got there?

MUELLER: The warlords dominating the organization. [Laughter] They were independent fiefdoms.

BERGEN: How did that cause problems with what needed to get done?

MUELLER: It was hard to get [any] two fiefs to talk to each other, at least in a meaningful way. It's a natural thing. Each was doing what it thought was right. And from their point of view, it probably was right, but from the standpoint of getting the program done, they had to work as a team. And more than that, we had to have much better communications across the centers and the contractors than we had had up to that point in time. The success or failure of

a program like Apollo depends upon all of the people doing the actual work understanding what it is that they are supposed to do and how that contributes to the overall program's success, the overall system.

In particular, in the case of Apollo, it was essential that that communication be on a very rapid level, [and] also on various levels. You couldn't do it just on the design; it had to be on how it was going to operate and how you were going to handle safety, and the safety had to be built in across the board, as well as all of the other disciplines that are required for a successful program.

One of the challenges was to make each of the program offices, both in the centers and at the contractor, realize that all of those disciplines were essential and that they had to be addressed early on, if we were, in fact, going to carry out a successful program.

BERGEN: And you were able to make those changes so that that communication was possible. Some people said that you had a lot of management freedom when you were in your position at NASA. Do you agree with that?

MUELLER: Oh, yes, indeed, much more so than is currently possible anywhere in the government, that [is] in the public sector. The only programs that have that kind of management freedom now—and that's pretty limited—are the black programs.

BERGEN: Why do you think you had the freedom that you had?

MUELLER: Because President [John F.] Kennedy said, "We're going to land on the Moon by the end of this decade," and no one wanted to be accused of interfering with that.

BERGEN: That's a good reason. When you came to NASA, you made some personnel changes, and one of those was to bring in General Sam [Samuel C.] Phillips. Can you tell us about him and why you brought him into the organization?

MUELLER: General Phillips was probably the best [program] manager that I've ever [known]. I'd known him when I was at TRW [Thompson-Ramo-Wooldridge], or STL [Space Technologies Laboratory], and known of his work, furthermore, in the B-52 bomber. He had a long career of very outstanding management responsibilities and successes.

So when I went back to NASA, one of the first things I did was to seek support from the Air Force, to bring in some people who were knowledgeable about program management, because NASA never really had the opportunity to manage programs of any size before. So they didn't have the infrastructure to be able to carry it out, to carry out a program like Apollo.

So, [I asked] Bennie [Bernard A.] Schriever, General Schriever, [to detail] them to me [(Sam and about two hundred Air Force officers), and] after some reasoning with his bosses, … (they were kind of reluctant to support it), but, on the other hand, they wanted to see the program succeed from a national point of view. That was a turning point, really, in the program itself, because, until we had a sufficient infrastructure to be able to put in place the kind of management practices that are essential for a system-wide approach, we were having trouble.

So, the combination of that plus the establishment of autonomous program offices reporting back to Sam Phillips in parallel with the reporting of the center directors back to me gave us the kind of insight and controls we needed to carry out the program.

BERGEN: Were there any other personnel changes that you made, that you felt were significant?

MUELLER: Quite a few. In fact, one of the things I did was to, early on, the centers had been providing people to our systems staff at headquarters, and many of them, a fair number of them, maybe twenty, were misapplied. So I went back to the center directors and said, "Look. These guys aren't going to be able to contribute to the program. I'm going to give them back to you." And that created quite a bit of a controversy and, in fact, eventually led to the formation of headquarters unions, because at that time there were no unions at headquarters.

These people were not as competent as we needed. You know, if you are going to run a program, [you've] got to have the best people in the organization working in that program office. These [people] didn't quite measure up. But it was an interesting experience.

BERGEN: It sounds like it. When you first came in—

MUELLER: It also turned out, the centers really didn't want them back. [Laughter]

BERGEN: [Laughter] They were trying to pawn them off on you. When you first came to NASA, you asked John [H.] Disher and Del [Adelbert O.] Tischler to conduct an investigation of the Apollo schedule. Do you remember that?

MUELLER: Vividly. That was an off-line kind of thing, and we were trying to figure out how we could get to the Moon in time, and so they went off and looked at what we were doing, and came back saying, "There's no way you're going to be able to do that." … I shared that review with Bob [Robert C.] Seamans [Jr.], and he said that, in effect, "Well, you know, you've got to burn that [report] and start over …, find out how to do it."

Well, I had already decided [how] I was going to do it, but I wanted to be sure I had the support from Bob, who did … was, in fact, a tremendous supporter.

BERGEN: And you made several changes in procedures, some of which we talked about last time, like the all-up testing, but you also instituted a program called the concurrency program, or also called alternate paths. Can you tell us about that?

MUELLER: I hadn't thought of it in that sense. In fact, those two are contradictory.

BERGEN: Explain that to us.

MUELLER: Concurrency. But we were doing things concurrently, or had to, and that meant that we were carrying on the Saturn IB Program at the same time as were carrying on the Saturn V Program and, at the same time, the Gemini Program was carried on. We set up separate program offices for these various activities. We … eventually [curtailed] the Saturn IB [program]. [Marshall had] already built some vehicles, so there wasn't any [reason for] not using them, and [later] it turned out very useful to have them. But basically they were not in line to getting to the Moon.

What we did was prune out those things that were not directly involved in getting to the Moon. Then we tried to provide all the [alternate] paths … we could, [so as] to have some reasonable assurance we were going to get there in time. The Saturn IB was essentially a backup to the Saturn V, in the event the Saturn V wasn't completed on time. Now, we couldn't have gotten to the Moon with the Saturn I, but, on the other hand, we could have made a pretty good stab at it. So we went down parallel paths in some instances, wherever we could, so that failure of one development didn't impact the total program.

BERGEN: Can you think of another example besides the Saturn I and the Saturn V?

MUELLER: Well, we carried out, for example, two different development programs for the tanks, relatively small things. There were two kinds of high-pressure tanks that we carried on board, that we carried on in parallel until we got one that was lighter and worked.

We did that wherever we could, we had parallel programs. For example, in the case of the lunar excursion module [LEM or LM], we had two guidance systems on it, one that was a simple one and another one more sophisticated, … either one of them could carry out the landing, but [one] without the bells and whistles that the main line did. But we had a backup there.

BERGEN: Is that kind of program something you think that would be feasible in today's atmosphere and industry?

MUELLER: In industry, probably, but in NASA, probably not.

BERGEN: You're noted as crediting the Apollo Executive Group [AEG] for the success of Apollo. Can you tell us who was in this group and why they were successful?

MUELLER: They were key to the success. So was the Scientific and Technical Advisory Committee [STAC]. [The members of the AEG] were the CEOs or the general managers of the [Apollo and Gemini] contractors, our major contractors. And it is always amazing if you can get the CEO to come and see what the total program is and what his group's problems are, how rapidly those problems get addressed and solved. It is a technique that you can only use when you have a program that's interesting enough so the CEO will come. But if he

does, then you've really solved many, many of the problems that plague a lot of programs. The other group, the STAC group, was equally effective, but with our external world.

I highly advise … anyone that's running a large program … to get the [CEO's of] the contractors who are doing the work involved. And we're doing that here [at Kistler], of course.

BERGEN: Great. Now if it's okay with you, I'd like to talk about Gemini. That's something we didn't touch on in our last interview.

MUELLER: Gemini was a stopgap program, if you will, yet we tried to make it as germane to the main line as we could. Chuck [Charles W.] Mathews did a marvelous job on managing that program, and he and Bill [William C.] Schneider were the two people that, on the part of NASA, had much to do with the success of the program. But we were talking while we were reformulating the program, when I first came in, about canceling the Gemini Program.

BERGEN: Really?

MUELLER: And probably would have, but Bob [Robert R.] Gilruth made the cogent argument that … there would be a two-year gap between when our last manned flight [of Mercury] and the first flight we could reasonably expect to have on the Saturn vehicles, and that would not be good. Besides that, they were fairly well along on the development of the Gemini, and wouldn't it make sense to finish that and have some flights in the meantime and maybe we can learn something in the process.

So we did, and it turned out it was very useful that we did, because we learned a good deal about how difficult it was to operate in space in a spacesuit. In fact, the first five space

walks, none of them accomplished anything useful except getting out of the cockpit, [and] successfully getting back in.

But then the sixth—I guess it was the sixth—and last one, we finally had learned about neutral buoyancy. Buzz [Edwin E.] Aldrin [Jr.] was busily learning how to operate a spacesuit under zero-G conditions. Of course, the first thing you discover is the reason they're all exhausted from working in a spacesuit is that they're trying to bend the spacesuit, and that's a lot harder than doing the work. But you have to learn how to not fight the spacesuit, but let it help you solve your problem, and that's what we did in the neutral buoyancy facilities.

Incidentally, that was where I learned to scuba dive, was in the neutral buoyancy facility, or started. It was my first scuba diving. Because I was trying to understand how hard it really was to do some work in that kind of an environment.

BERGEN: Harder than it appears.

MUELLER: Oh, yes. The program itself, one of the interesting things about the program is that it was going on the usual kind of a schedule that NASA had been used to, and it was beginning, however, to not only fill in the gap, but also to overlap the Saturn I and the Saturn V Program. We just couldn't afford to have that kind of an overlap.

So at one of our meetings of the Exec Group, I pointed out that we simply were not going to be able to extend the program, the Gemini Program, past the time when we had our first Saturn launch. So however many flights we got off is how many flights there would be in the program, and there were—how many Geminis were there?

BERGEN: Twelve.

MUELLER: Twelve? I think there were thirteen. Maybe it was twelve. I guess it was twelve. At that point in time we had flown the first three, and so we had nine more to go. I said, "Look. Unless we can get these things flying on one-month centers, we're going to have to terminate the program." And I remember Mr. Mac [James S. McDonnell, Jr., President of McDonnell aircraft Corporation] calling me and saying, "Are you really serious about that?" And I said, "Dead serious. If you can't figure out how to get these things launched on one-month centers, we're going to terminate whenever we get to this point in time."

And lo and behold, they went back and figured out—the Titan group, who were launching these things at Sunnyvale [California], what is Lockheed's group there, and the McDonnell-Douglas troops, John [F.] Yardley, got together and figured out how to get them launched on one. In fact, at one time we launched two of them on one-day centers. So it was amazing what you could do when you set your mind to it and get out of the box of what you're used to doing.

BERGEN: You mentioned that when you were considering the option of canceling Gemini, that there would have been a two-year gap between the missions, the last Gemini and the first Apollo one. What were some of the negative aspects of that to you?

MUELLER: Not the last Gemini; the last Mercury.

BERGEN: Oh, the last Mercury. Okay.

MUELLER: And the first Apollo.

BERGEN: So that was before any Gemini missions had even been flown.

MUELLER: Right.

BERGEN: Okay. So what were some of those negative aspects of having it?

MUELLER: In order to maintain public interest and support for a program, you have to be doing something that you can report to the public. Progress is important. So without a Gemini Program, about all you'd do is send some pictures of—well, I don't know what we'd send of. Of engine tests out in L.A. [Los Angeles, California], which, after a few of them, you don't have much publicity associated with it.

You also had the whole astronaut crew there, that were interested in doing some flying as well, and they needed to have the practice of working in space before they went off to the Moon. So it was both something that needed to be done in terms of maintaining the skills of the astronaut crew and to make sure the public support continued. As you know, the first Gemini flight we came up with got a ticker-tape parade down New York.

BERGEN: Gemini IV, probably, because you realized the importance at that time.

MUELLER: Right.

BERGEN: The first EVAs that were done, even though the Russians did beat us.

MUELLER: Sure. But we also had to be able to do that anyhow.

I don't know, what else would you like to know about Gemini?

BERGEN: The paraglider program.

MUELLER: Where did you hear about that?

BERGEN: [Laughter] In the Gemini history book.

MUELLER: [Laughter] I see. Well, there was a desire on the part of some people to build a paraglider to bring the Gemini capsule back to a controlled landing. The problem was that paragliders at that time had a terrible habit of failing, and we didn't think it would make good publicity to have the wings come off the reentry vehicle. [Laughter]

I've always liked the idea of a paraglider. I think it's a great idea, but making one as safe as a parachute is hard. Parachutes aren't all that safe either, because occasionally they don't open. Fortunately [Mueller knocks on wood] we have not had that problem, and they're getting so good now that I don't think that's a likely problem. But with the paragliders at that time, with Gemini, it was a likely problem, and there just wasn't any point in taking that risk.

BERGEN: A lot of time and money was spent on the paraglider program. Did you see any benefits that came out of that research effort?

MUELLER: Yes. The paragliders are much safer now and people are flying around on them, which wasn't being done at that time. So that's a fallout, if you will, of the Apollo Program. And that work has been continuing now for thirty years, and they're getting so that they're—well, as a matter of fact, they're thinking of using paraglider on the X-38 program, the crew rescue model. So it's not in vain, but it wasn't something that we needed or had to have in Gemini, and there's no point in doing something that it would be nice but not necessary, particularly in a program that is time-critical and as sensitive as the Gemini Program was and as Apollo was.

BERGEN: By that time you'd already decided to land Apollo in the water, so it wasn't going to benefit Apollo, right?

MUELLER: Actually, we tried to build the Apollo capsule so it would land equally safely in water or land if it didn't go the way it was supposed to go, and I don't think that the capsule would have been damaged by a land landing either. The shock level would have been slightly more. Well, it turns out landing on the water at the speeds we do is not much different than landing on land, which we discovered as we were going on and developing the landing system.

We did quite a lot of testing of landing systems in the development of the program, and we were all somewhat surprised at the fact that water landings were not substantially safer than land landings. The principal reason for not landing on land is that coming down on parachutes, you drift, and so you don't know exactly where you're going to land. At that time our ability to control the reentry profile was limited, and so no one wanted to take the chance of landing at White Sands [New Mexico] and ending up in Albuquerque or someplace.

BERGEN: Gemini also helped show that they could have more precise landings.

MUELLER: Yes, it did. In fact, the troops began to bet on how close they could come to the landing spot. The one that got closest used the computer-aided landing. [Laughter] As you should expect.

BERGEN: One of the Gemini missions, one of the first longer ones, was Gemini VII with Borman and Lovell, and in that mission there was some discussion about whether they

should wear their suits throughout the mission. Were you involved in those decision-making processes?

MUELLER: Well, I'm sure I was consulted and involved in it, but in that case the final decision was made by Bob Gilruth. Of course, once we got to Apollo, there was room enough to take off suits, and that made all the difference in the world. I never was hung up on having everybody stay in suits. In fact, I kind of encouraged it to get out of them.

BERGEN: It makes long-term space flight more bearable for the astronauts.

MUELLER: Oh, yes, indeed. [Laughter] It doesn't even have to be very long term.

BERGEN: [Laughter] That's true, too. You've talked about some of the importance of Gemini. Are there any other lessons learned about Gemini that you think were especially important for Apollo?

MUELLER: Well, obviously the whole reentry system and the ability to control landing points were important, although I don't think there was ever any doubt about that. Perhaps the most important thing was the demonstration that you could put a program together like that and, in fact, carry it out on a schedule, which was kind of unique at that point in time, as was Apollo.

BERGEN: That's true.

MUELLER: But neither of those would have been possible without the structure of program offices that we set up, in my view.

BERGEN: That's something that's often overlooked. People seem to look at the technical things and not the importance of the management.

MUELLER: Right. And yet that's the key, one of the very real keys, to the successful program. I don't know whether I mentioned it last time, that one thing I learned from that is that if a single center has the entire program under their control, they can, in fact, get the job done if you have sufficient outside pressure to cause it to happen. But if you have multiple centers working, you almost have to have an arbitrator, a person outside of the centers, who is controlling the total program. And a number of illustrations of that [are evident] in the successive programs of NASA.

BERGEN: Speaking of management again, most of the managers with the NASA and most technical industries of that nature are engineers. Are there some difficulties in teaching engineers how to be managers?

MUELLER: Well, not [all] engineers become managers or are good managers. It's just who and what the personality is, I guess. I would never imagine myself as being a manager. In fact, I spent most of my first twenty years of work—well, fifteen, anyhow—avoiding being a manager and trying to do research. So I was dedicated to being a research person. Then I inadvertently got into Ramo-Wooldridge, and began to solve problems there, and it turned out management was one of them. [Laughter] So I got co-opted, if you will.

BERGEN: What were some of the hardest parts of being a manager?

MUELLER: People. Always is. And having a clear enough understanding of what needs to be done and being able to communicate that to people. And I'm not particularly good at that,

at least not in the large. But you have to have a vision of what you want to have done and then you have to figure out how to implement that vision and get everybody else involved in implementing it. The first thing you know, everybody's just as gung-ho as you are and they go do it.

BERGEN: One of your visions was a reusable space transportation system.

MUELLER: Yes.

BERGEN: Can you tell us how that got started?

MUELLER: Yes. We were trying to figure out what came after Apollo, and we counted up how much it cost to get a payload into orbit, and it was clear that if we were going to have a commercial space industry, we needed to reduce the cost of getting into space.

At that time we were talking about the idea of doing microgravity production in space, industrial production in space, taking advantage of microgravity, taking advantage of the space environment, very low pressures, very low contaminants. So, as you know, we set out to do a long-range plan following Apollo, and we started that about 1967.

One of the things that became apparent was that, first of all, we had to have a goal we were going to search for, which was our next goal, and then we began to lay in what it took to reach that goal. We started very early on looking at a space station as the next step in Apollo, and as we got into trying to figure out why the space station was going to be the next major step, it became clear that you were not going to be able to sustain that on a basis that was reasonable unless there was something beyond the space station. There wasn't enough to do in a space station and make it a worthwhile investment, at least in our view at that time.

Furthermore, we said if we were going to have a space station, we had to have some way of putting it up there and supplying it, because otherwise it was just too expensive. What's going to happen? Now it's happening and it's still too expensive. [Laughter] But at that time we were more oriented towards making something that was going to be really feasible.

As our study progressed, though, it became apparent there weren't enough things to do in a space station that would justify the expenditure, and so we decided that we needed a more far-reaching target. We decided that the thing we needed to do was to build a total space transportation system and that we needed to be able to have nodes in that transportation system so that you didn't have to take everything all the way there and back again. So the space station became the first mode.

Our plan called for a second node around the Moon as the next step in space, and then there are interorbital transfer vehicles and excursion vehicles for the Moon and back again. You had a complete transportation system like a railroad system, if you will, in space, made up of components to travel from one place to the other and carry the cargo on separate vehicles as you went. And then that plan also said, well, gee, that's something we've already done, but we're going to learn from that and then we're going to put a node out around Mars, and we would move then from Earth orbit to Martian orbit. The energy required is not that much different from going to the Moon, when all is said and done. So that was the structure.

That led to the Space Shuttle, because that was clearly something we had to have if we were going to get the cost down, which was at that time a fully reusable vehicle. That is, it didn't throw away the external tank and it didn't dump the first stage into the ocean. It flew back to the launch site. That was the thing whose entry cost level was high, higher than Jim [James C. Fletcher] was able to sell to the White House, the budget people there. But, nevertheless, it was something that even they understood needed to be done, so eventually it started and got going. Actually, that was the first step that has taken place, and the second

step was the space station, but it was at that time we configured it as a refueling point, as well as for other things, and a passenger way station.

So, passengers went up there, got acclimated, went over to the interorbital transfer vehicle, to the next node in the transportation system where they, again, waited and did whatever they needed to do to get ready to land on the next body, then landed and started all over again. Grand vision.

BERGEN: It was.

MUELLER: And if we had followed through on the time schedule we set up, by now we would have a colony on the Moon and an outpost on Mars.

BERGEN: Why do you think that NASA wasn't able to carry through with that vision?

MUELLER: Vietnam War and the repercussions of it. Very simply. We spent all of our good will and resources on a war that, well, either shouldn't have been or we should have won. You don't go into war half way, as we're demonstrating in Iraq.

BERGEN: We haven't learned from our mistakes yet.

MUELLER: No. Never do. You always have new people, and they all relearn the mistakes. It's one nice thing about living long enough, you hopefully do not repeat the mistakes you did earlier. [Laughter]

BERGEN: [Laughter] It's true. What do you think has been the impact on NASA of a partially reusable Shuttle as opposed to a fully reusable Shuttle?

MUELLER: Well, it has caused a continuing review of whether we ought to be in space at all, and it is something that has really hobbled the space program over the last two decades, because so much of the funds that could have been used elsewhere are being absorbed in flying the Shuttle.

BERGEN: You mentioned, when we were discussing Gemini, if Gemini hadn't existed, there would have been a two-year gap. There was longer than the two—several years between the ASTP [Apollo-Soyuz Test Project] mission and the first Shuttle flight. What impact do you think that had on NASA?

MUELLER: It sure called into question the whole management and the whole space program itself. There were successive efforts to cancel the program and cancel NASA, for that matter, within the Congress. Fortunately, wiser heads prevailed, or at least politically wiser heads prevailed. But it's been a drag. It is a drag. It uses up funds unnecessarily, and yet the cost of replacing it is now very large indeed.

To me, the amazing thing is, the Shuttle has not been superseded by a follow-on Shuttle long before now, because obviously a design that was built, designed in early 1970, should not be the thing we're flying today, twenty-eight years later. It is one of the characteristics of government that it does not depreciate things, and if you had a depreciation schedule, you would have replaced the Shuttle by now. I think that's important, but something the government seems to be unable to appreciate. They think that an investment is immutable and never wears out.

BERGEN: You've been called the father of the Space Shuttle. How did you get that title?

MUELLER: By forcing it through. You know, in order for the Space Shuttle to be approved at all, I had to get the Air Force and all of the centers to agree that we would replace the existing arsenal of expendable vehicles with a reusable vehicle, thus saving everybody huge amounts of money. It was that agreement that I managed to get with the Air Force and the DOD [Department of Defense], really, and the NASA centers, as well as our management there, that made it possible to go forward with the Shuttle.

BERGEN: What kind of opposition did you encounter?

MUELLER: Well, everybody wants to do their own thing, and who was going to depend upon NASA to produce this marvelous new machine? But eventually they did, because everybody wanted a low-cost access to space, and no one had a better idea. Still don't.

BERGEN: Do you think, in hindsight, looking at the circumstances that surrounded the Shuttle development, that it would have been possible for NASA to develop a fully reusable Shuttle?

MUELLER: If any of our administrators had taken the position that the only way it makes sense to build this vehicle is to make it fully reusable, yes, it's going to cost more to build it in the first place, but it will save you more money in the long run than you can possibly spend on the front end. They said, "Well, we can't do that." "Well, then we can't build it. What would you like us to do then, since you don't like what we're doing?" Now, politically that's not politically correct, but it's the only way you get some of these things done. Either that or else have Russia decide they're going to build one and then you can do it. But even that didn't faze our folks.

Our whole economy is based upon what can you do next month or next year. If it's longer than a year away, it's infinite. That's the whole mind-set of the management of most of the corporations, certainly of the government. Two years is an infinity. One year is barely conceivable.

BERGEN: It makes it difficult for research and development.

MUELLER: It does indeed. It's amazing as much gets done as it does. Mostly it's inertia. I mean, doing things in a constructive way.

BERGEN: During your career at NASA, were there any people in particular that had a significant impact on you?

MUELLER: Oh, yes. Lots.

BERGEN: Give us a few examples.

MUELLER: Well, take Jim Webb or take Bob Seamans or take Homer [E.] Newell. There are different kinds of impacts. Or take—a friend of mine [Jim Beggs], the guy that just left NASA at the time of the *Challenger* [STS-51L]. At that time he was head of the Office of Technology. I know him very well. Anyway, he had an impact, because we worked with him in his center in doing things like the gyroscopes that were used on the Skylab, really was the first real application of gyros for attitude stabilization. And then, of course, there was Bob Gilruth and Wernher [von Braun] and Kurt [H. Debus] were tremendous influences, as were George [M.] Low and [Joseph F.] Shea and Eberhard [F. M.] Rees and a whole host of people.

And then, of course, at another level, Chuck [Charles W.] Matthews and, I don't know, you can just name all the key people. They all had a tremendous impact on me and maybe I had some small impact on them.

BERGEN: I'm sure you did. Looking back at your time at NASA, is there anything you would have done differently?

MUELLER: Well, I wish I had been able to glue that plan down a little more firmly. On the other hand, I don't know that it would have made any difference, because when I left, Tom [Thomas O.] Paine was thoroughly in support of the plan, but then he left. I don't know, if I had stayed on, whether it would have made much difference one way or the other.

BERGEN: What do you feel were your greatest successes?

MUELLER: Getting to the Moon on time. What else? [Laughter] No, actually, probably even a greater thing was putting in place a follow-on program that would begin to exploit what we'd accomplished in Apollo. The real problem with Apollo was that it was a one-time event, essentially, and it wasn't built to carry on a lunar exploration program, for example. But we did put in place the program that exploited what was left of the Apollo thing, Skylab and those programs, and then laid the groundwork for what were the first two steps in our long-range plan, which we're now implementing. I think we lost a vision, and Dan [Daniel S.] Goldin is beginning to bring the vision back, which is great.

BERGEN: What did you feel was your greatest challenge?

MUELLER: One? [Laughter]

BERGEN: You can give several. [Laughter]

MUELLER: The first one was getting the team put together, getting all of the disparate groups within NASA working together to accomplish this goal. That was a challenge.

A challenge to convince the White House, with its PSAC [President's Science Advisory Committee] and its space—I don't know what they call the space office—that, in fact, we could do the job, because PSAC said, "It's ridiculous. You can't get there from here." Not quite that way, but they were skeptical, shall we say, and very competent people, but all scientists.

Then there was the problem with getting Congress to believe that we were going to be able to do it, and convincing them that, hey, we knew what we were going to do, we were doing, and we were going to be able to accomplish it without embarrassing them. And that's why we set up the monthly meetings with our oversight committee in Congress, which paid off tremendously after the fire, because we had built that confidence and that liaison.

Another very interesting challenge was, as you probably are aware, the Air Force had great space ambitions, and I was fortunate enough, being sponsored, if you will, by the Air Force to some extent, since I'd been working with the key players in the space activities back at STL, and that was a tremendous help. But, nevertheless, it was a challenge to make sure that we were cooperating with all of the branches of the DOD. We needed the continuing support of the Air Force and the Navy for our retrieval operations with the astronauts and the capsules.

Then there was the challenge of keeping the public, because we had the problem of convincing the public, at least some parts of it, that this was a good thing to do, was great for the nation and so on. So there was a fair amount of PR [Public Relations] required, which all interacted all through the thing.

So, yes, there were a few challenges. Not to mention getting the design so that it would work and getting the contractors to share the same vision we had, which is not always that easy.

BERGEN: You mentioned how important it was to get the public to support your program, which was a little easier in Apollo. Is there anything you think NASA could have done afterward to better get the public to support what they were doing?

MUELLER: Yes, they should have hired a very good PR firm. Really. Not just a sycophant, but a PR firm that really understood, like President [Bill] Clinton has. A PR firm of the first order.

BERGEN: [Laughter] That's true. You've talked about the Space Station a couple of times. What is your opinion of the International Space Station?

MUELLER: Well, it's a great step forward. I think that it has been implemented in an awkward fashion, a fashion that probably will end up with the U.S. building it anyhow. We probably could have done it better and easier by itself, but, nevertheless, it's important in the long nature of things to bring in the other nations of the world. In fact, in my view, at least, the U.S. has been far too parochial in sharing its talent and its expertise with the other countries in the world, and doing it in a constructive fashion.

My opinion is—it's an opinion—that the Ariane Program would never have been consummated if we had been willing to fly all of the satellites that the Europeans wanted to build on our launch vehicles. We wouldn't be in the position we're in now, where more than half of our launches are done by the Ariane vehicle. We tend to be short-sighted and parochial as a nation and not to really understand the importance of a global economy. We

still act as though we were independent of the rest of the world, and that's not really true by a long sight.

Wendell Willkie was probably correct: it's one world. But he couldn't sell that idea then, and we probably can't sell it now, although the Space Station is a step in that direction and it's forcing people to work together. But it isn't able to solve all of the kinds of international problems—intranational problems, international problems—we're dealing with. But it's a start, and for that reason I think it's good. From the standpoint of getting a space station, it's an awkward way of doing it.

BERGEN: You mentioned how other countries are getting involved and are involved in space travel and space flight. As your company is an example, we have more commercial enterprises getting involved in that. What do you feel NASA's role is in the future of space flight?

MUELLER: Well, it ought to be the leader of the vision of human travel and occupation of the planets, I think, and we ought to have a clear mandate, "Let's get us to Mars," and drag the rest of the world with us. That's my view of what NASA could contribute most effectively. In the meantime, though, it is, and continues to be, one of the great resources in terms of research and development of new technology, and that ought to be clearly defined as its role, one of its roles. So it ought to have two roles: one, exploration; the other one, building the technology that we can exploit in our commercial activities.

We [Kistler Corporation] would dearly love to have the support of Langley [Research Center], for example, on aerodynamics, because we're flying almost blind in that arena. But the way it's set up, we really can't utilize that great resource. The same thing is true of Ames [Research Center] and its ability to build thermal protection systems for reentry vehicles. Again, we really can't utilize that. I shouldn't say we can't, because we are drawing on their

expertise, but we can't do it in a way that they're working with us. We just simply are learning what they've done.

In any program like this one, we need to have joint working groups to solve the problem. We're struggling through, but it would be a lot easier if we had the same kind of cooperation the X-33 is getting.

BERGEN: You've been talking a little bit about Kistler here in response to my last question. Why don't you tell us about what you're doing now.

MUELLER: Well, I'm doing what I set out to do with the Space Shuttle, and that's building a fully reusable launch vehicle. Again, it wasn't really feasible to do that until there was a large enough market for satellites, which the commercial communication satellites provides to justify the investment in the vehicle itself.

With that, however, it's still very difficult to raise enough money to build a vehicle, and the thing that we're doing, and have done, is to draw on a whole host of people. Most of our money comes from overseas, interestingly enough. When I started out on this thing, I would have thought that once we got past the initial stages, that we would be able to draw on resources in this country. And, of course, we had established a financial arrangement with three investment banking houses to float a bond issue this last summer, but the market disappeared about the time the issue appeared, and that was a double whammy because a lot of our money comes out of Asia, or it has come out of Asia. So we've been struggling.

The real problems we have encountered are not the design, because we had a pretty competent crew of designers. A lot of my friends came in to help or to save me. So we had probably the best design team in the country pulled together here, a combination of consultants and employees, but mostly consultants. That, however, was a challenge, because we were trying to build something that was not only reusable, but was also operationally very

simple and very inexpensive to operate, because in the long run it's the cost of operations that determines the success or failure of this program or any program.

In fact, going back to the Shuttle, one of the chief problems with the Shuttle is it wasn't designed for operational simplicity. It wasn't designed to use as few people as possible to fly it, although that was what we set as a criteria when we started it. It was supposed to be an airline you fly up, fly down, and refuel and fly again. We didn't [consider the actuality] I had set a limit of 150 people in the launch crew. Sure enough, we could have designed it to be that way, but instead the way it got designed was with about 15,000. And that makes the difference. That's one of the very large costs involved in the Shuttle Program. It's one that we've deliberately avoided [at Kistler].

We expect to be able to fly these things with about thirty people on the ground and turn it around in nine days rather than the several months it takes to turn a Shuttle around. But to do that, we had to take a look at every part of the vehicle to make sure that it was as simple, as foolproof, and as reliable as possible so that we were reasonably confident that there wouldn't be anything go wrong on a flight or really almost never.

Nevertheless, we put in a health monitoring system so that every part of the vehicle that is susceptible to failure will tell us when it's getting ready to fail so we can change it out before it fails. That's the objective of the health monitoring system, and that's a key part to a successful program of this sort, a reusable vehicle program. It's something the aircraft industry has learned over many, many years, and doesn't yet do very well, but does a lot better than the expendable launch vehicle people do, since each flight of theirs is a unique event. We have the advantage of being able to fly over and over again, find the weak links and replace them. At least that's our theory.

BERGEN: You mentioned the operating costs of the Space Shuttle. How do you feel about the privatization of the Space Shuttle with USA [United Space Alliance] taking over most of the responsibilities?

MUELLER: I just think it isn't an economic thing to do and doesn't make any sense, because they aren't going to be able to pay for its operation. It's just too expensive. The only real use it has at this point is for the Space Station, and I suppose you try to charge people, but you can't charge them what it costs. There are some things that can be privatized, but you ought not to take a vehicle that was designed for 15,000 people to operate and then expect it to be a commercially attractive thing.

Now, I know the USA is hoping that they can use marginal pricing so that the government pays for the launch and they take the profit from carrying the payload, and that's not all that bad if the cost to the government is decreased in the process, but if it turns out that it stays the same, it's not a good deal at all. It would be better selling the space itself.

BERGEN: That's true. You mentioned that the status of commercial satellites has just now gotten to the point where a reusable launch vehicle is a feasible option.

MUELLER: Yes, you can afford to build one now.

BERGEN: So what did you do between the time you left NASA and when you started—

MUELLER: I went and ran a company, a couple of companies. I went to work for General Dynamics and ran their defense systems, and then I got a job as CEO, Chairman of the System Development Corporation [SDC], a corporation that was originally a not-for-profit, working for the Air Force in developing the software for the Air Force systems, early

warning system. Most of the software that SAC [Strategic Air Command] has was built by SDC. And ran it for about twelve years. Then I retired. Well, I sold … the company to Burroughs [phonetic] and stayed there for a year or two, and then retired.

At that time I was President of the International Academy of Astronautics, so I was working on that, and went out and did some investing in various things and actually ended up running a farm, a jojoba [phonetic] farm. That was an experience, clearly one not to be repeated very often in one's life, but, nevertheless, very interesting. Jojoba is a replacement for sperm whale oil. It was the time when the sperm whales were being protected, and it seemed like a good idea to do something that would replace that commodity. Turns out to be harder to domesticate plants than it is animals. [Laughter] And so it took a while to get it to where it was a reasonable thing to do.

Then I got involved with [Kistler] because I always have been interested in reusable launch vehicles ever since I thought about them, and this was a great opportunity to do something constructive and to have some fun. That's why my friends are with me, too.

BERGEN: That's important to have fun.

MUELLER: Right.

BERGEN: Looking back over your career and thinking about when you got into aeronautics and aerospace, would you have ever imagined where it would all lead you?

MUELLER: I never would have imagined I'd be in aerospace, although when I started as an undergraduate, I was thinking in terms of an aeronautical engineer, but it turned out where I was able to go to school, they didn't have aeronautical engineering. As soon as I got into mechanical engineering and discovered that, well, you do a huge amount of calculations,

when you got finished calculating all of this, you then said, "Well, we're not quite sure that works, so we'll just give it a factor of four for safety." And it seemed to me you could do a lot of other things much simpler than to do all of that calculation and put a factor of safety of four on it. We're a little better now. Some of our people will even go down to one and a half. But the uncertainty was still there, so I switched to electrical engineering, and my undergraduate degrees were in electrical engineering. Most of my minors were in physics.

Then I got a fellowship at Purdue [University] and went there for one year, finished my master's degree there, working on the precursor to television systems at that time. Then I got a job at Bell Laboratories and worked in their television department until the war came along. [Then] I got into radar and electronic tubes and built some of the first millimeter-wave tubes that were ever built, and did a lot of research on propagation, on antennas, on you name it—built traveling wave tubes in the millimeter-wave range, and so on, which they're finally now using some of that technology, what, forty years later. But Bell Labs was always fairly well ahead.

Then I decided that I needed to know more, because I found out that although I was a member of the technical staff and all my bosses were members of the technical staff, most of them had Ph.D.'s and knew more than I did about physics and life. Besides, I'd always been interested in physics. So I went back to Ohio State [University] and taught electrical engineering and took a degree in physics there.

I was finally rescued from teaching by Ramo-Wooldridge and the ballistic missile program, and that's my first and only real encounter with space activities, which has continued now for thirty years or so.

BERGEN: I want to see if Carol has any questions at this point.

BUTLER: I have a few. Hopefully those thirty years have been good years.

MUELLER: Oh, they've been very interesting, career after career. I used to say I couldn't keep a job longer than about six years, and then I stayed twelve years at SDC because I couldn't sell it. [Laughter]

BUTLER: I'd like to go back a little bit to when we were talking about the Gemini Program and the possibility of not having the Gemini Program. You talked about the reasons why that ended up not being a good idea. I was wondering if there was any discussion at the time about how the Apollo missions would have gone if Gemini hadn't happened. Would the early Apollo missions have done the EVAs?

MUELLER: Yes. As a matter of fact, the [Apollo] one was set up to do that kind of support activity, and essentially what we were able to do was to short-circuit that with the Gemini Program … But originally it was contemplated that the Saturn I would have a number of flights in which all of this work that we did in Gemini would have been carried out. And they could have been, but we probably would not have landed on the Moon in the decade.

BUTLER: Sounds like you made the right choices, then. Also talking about Gemini, you talked about the paraglider program, but one of the other differences in the Gemini Program was the escape system, that Gemini used the ejection seats rather than the launch escape tower. Were you involved with that choice?

MUELLER: I was kind of involved in it, but not in any depth. I was involved in the escape system on Apollo, but I never could persuade them that it didn't make any sense. It's like putting ejection seats in the Space Shuttle. They're useful for about one minute. Not even that long. Thirty seconds of the flight path. So after that, they aren't any good, so you're

better off with putting a little more weight in for safety and not having this kind of escape route.

But, unfortunately, all the astronauts are pilots, and so they have the idea that they want … to have an ejection seat or the equivalent thereof. I never was able to persuade them differently. The Shuttle just simply doesn't accommodate ejection seats, although they looked at it very hard. So they didn't put it in there.

Butler: That would be hard, when you have a crew on both the upper deck and the lower deck, trying to—

MUELLER: Eject.

BUTLER: Hopefully they have found a good solution. Of course, hopefully they'll never have to test the solutions for escaping on the Shuttle.

MUELLER: Yes. I prefer that alternative. I would not like to try.

BUTLER: I'm going to jump forward a little bit now. You were talking about the plan for following on Apollo with the nodes and the step-by-step system, and eventually getting to Mars. When you were planning this and then when you did see the Shuttle was going to be the first step and it would take a little while before the others could follow on, did you ever realize or even imagine that it would take so long to achieve that plan?

MUELLER: Well, no, I couldn't imagine it then, can't imagine it now, but it's happened, really. But the plan we laid out is a logical plan, and so it's the kind of stuff you're going to have to go through. I think perhaps the greatest worry I would have is that politically we'll

decide to do an excursion to Mars instead of an exploration of Mars, because literally what we did with the Moon was to have an excursion to the Moon. That, at the time, is what we should do, but we didn't really follow up with the exploration of the Moon. We're just now beginning to do that.

Butler: Beginning with some of the unmanned probes that are going back, like Clementine, and more exploration of it.

MUELLER: Eventually it will be men, and it's just a matter of how soon the politicians decide this is something that's in the nature of fate.

BUTLER: Well, maybe if NASA could ever get that great PR firm, that would help foster the—

MUELLER: Yes. Yes, it's interesting. We did have resources in Apollo for PR. They were volunteers. But it is very difficult to sell space as anything other than a vision, and we haven't had any PR firms that have vision, that I've seen, because it really has to be faith that there's something there that's worthwhile. I always say, if we had been able to find some diamonds on the Moon, we would have been way ahead of the game. Then we would have had an exploration program.

BUTLER: Oh, definitely. Hopefully, one of these days the spinoffs and the applications will become more recognized.

MUELLER: Well, everybody seems to think they're magic. [Laughter] Just appear out of nowhere. And that's the problem. It does take a while from the time you have a new

technology to where you get it to play. When I left Bell Labs, for example, they had just discovered the transistor, and that was in 1946. It was twenty years later, in the ballistic missile program, that we finally got transistors to the point where they were reliable enough to use. In fact, the Minuteman Program probably did more to advance the integrated circuit work than almost any other thing.

BUTLER: Interesting. I guess you don't think about the stages that something has to go through from the initial conception to common usage, because most people don't hear about it until it is more common.

MUELLER: Right.

BUTLER: I did have one last question. We talked about Kistler and you becoming involved. What was it that actually got you involved?

MUELLER: A guy had promised me we would have enough money to build it. [Laughter] He's my partner, who's now trying to get the money to build it. So far he's only gotten 400 million, and we only need another 400 million, so we're halfway there. But the last half is proving to be a little more difficult than we imagined because of the Asian crisis and Russia going out of business, that kind of thing.

BUTLER: The world economy does seem to be in a little bit of a turmoil.

MUELLER: And, unfortunately, although we may not recognize it here, we're part of that economy, and it hasn't quite caught up with us, but it will.

BUTLER: Yes, it definitely will. That's all I have, other than to say I look forward to seeing Kistler succeed.

MUELLER: Thank you. We are, too. [Laughter]

BERGEN: We thank you for your time that you spent with us, and we enjoyed hearing about your career.

[End of interview]