ORAL HISTORY TRANSCRIPT

MAXIME A. FAGET
INTERVIEWED BY JIM SLADE
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SLADE: This interview was done with Dr. Max Faget at the Johnson Space Center on June 18, 1997. [The interview was conducted by Jim Slade for the Johnson Space Center Oral History Project.]

Dr. Faget was born in British Honduras on August 26, 1921, married to the former Nancy Carastro of Philadelphia. They have…three daughters and one son.

He joined NASA [National Aeronautics and Space Administration], which was then NACA [National Advisory Committee for Aeronautics], in 1946 at Langley, Virginia, to work in the Pilotless Aircraft [Research] Division [PARD]. He became the head of the Performance Aerodynamics Branch, where he proposed the one-man spacecraft later known as Mercury, numerous inventions, papers, and books which laid the foundations for today's space flight. He is the winner of the prestigious Guggenheim International Aeronautical Award that was awarded to him in 1973. It cited him for playing a major role in developing the basic ideas and original design concepts that have been incorporated into all the manned spacecraft flown by the United States.

An expert on vehicles suitable for reentering the Earth's atmosphere, he is particularly noted for his contributions to the basic configuration of the command module and to the development of the pressure-fed hypergolic engines on the Apollo modules.

Dr. Faget, it's an honor to have you here and to meet you and to see you here. To begin this discussion, I want to go right back to the beginning. You trained in mechanical engineering, I believe, at San Francisco Junior College and Louisiana State University.

FAGET: That's right.

SLADE: What led you to the aeronautical branch of that discipline? Did something in your childhood draw your attention? How come you went with wings?

FAGET: Well, I was the second son, my brother is two years older than I am, and we both got interested in model airplanes. Of course, he, being older, was always kind of the leader in breaking new ground. So we were very, very enthusiastic model airplane builders. When I [entered college] majoring in mechanical engineering, I minored in aero[nautics]...There were very few colleges at that time that dealt with a strict aeronautics degree.

I did have a background in aviation. Before the war, I got in the Navy and served in the submarine service. Another thing that goes back to our childhood, we not only built model airplanes, [also] we built model submarines.

SLADE: Operating?

FAGET: Oh, yes. These were rubber-band-powered submarines that would submerge in the swimming pool that we had access to. After they'd stay down for several minutes, they'd come floating back up when the propeller stopped running. They were a lot of fun to build.

SLADE: And these childhood experiences led you to the degrees you—

FAGET: Well, they led me into mechanical engineering, and they led me into an interest in both aviation and submarines. We were also avid sailors. We had sailboats, and we had experience in the water and experience with model airplanes.

SLADE: You were in the submarine service in World War II?

FAGET: Yes.

SLADE: Where did you serve?

FAGET: I served in the South Pacific. I got into the war rather late, but I did make two war patrols off the coast of Vietnam and had quite an experience, actually, in Phanrang Bay, which [was later used as a]… big base for our war in Vietnam.

SLADE: That was a very accurate shipping corridor for the Japanese during World War II.

FAGET: Yes. They would come up the coast, [their] idea was to stay as close to the coast as [they] dared stay. The only problem [for us] was the water was not very deep there. [But] we managed to sink a rather large tanker and got pinned down in shallow water, which is not a very comfortable place to be. [We] stayed submerged for twenty hours before we could come back up.

SLADE: This was diesel-power operating on battery at the bottom?

FAGET: Diesel power, no snorkel.

SLADE: It must have been getting really nasty inside.

FAGET: Well, [for silent running] you'd turn off all the machinery, which includes the air-conditioning. And this was a Sunday. We always had turkey on Sunday. We had to turn off the stoves just about the time the turkeys got up to about 150 or 160 degrees. It got to be pretty smelly. [Laughter] The turkeys started rotting.

SLADE: Fresh air must have smelled good, so you left the Navy and decided to go into aeronautical engineering, is that right?

FAGET: Well, my interest was to get into aeronautics right away. As soon as the war was over, I visited my professor at LSU [Louisiana State University], and he recommended that I go seek a job at NACA Laboratory in Langley Field [Hampton, Virginia], which I did, and I was able to get located there, and that started off my real aero career, of course.

SLADE: That must have been a thrill.

FAGET: Oh, absolutely. It was great to get started. The division was itself just getting started. It was just a few months old when I joined the Pilotless Aircraft Research Division [PARD] under Dr. [Robert R.] Gilruth. That was an ideal place to be. We didn't have the foresight that there'd be a big Space Age, but we did do a lot of different kinds of rockets, and stage [the] rockets, and everything else to fly various models of airplanes or parts of airplanes through the transonic speed regime and later on [at speeds] up to where aerodynamic heating would get to be significant. We could make a lot of tests in conditions that the wind tunnels were not able to [perform]. So we made a great number of flights.

We learned a lot about building rockets that would stay together during flight, which is very important, and finally, of course, when the time came for the country to have a space agency, they looked at NACA to be the cadre agency to [do this]...

SLADE: That was almost prophetic, your getting into rocket-powered flight for pilotless vehicles at that early time, because you went there in 1946, isn't that correct?

FAGET: That's right.

SLADE: Who was there at the time? It seems that engineers go in classes, and you seem to stay together, or at least closely linked, through all your careers. Who were the big players?

FAGET: In the Pilotless Aircraft Research Division, there was, of course, Bob Gilruth and Paul [E.] Purser, who was Gilruth's assistant when we first started down [t]here, later retired Guy [Joseph G.] Thibodaux, who was, of course, head of our Propulsion Division here for quite a while; and Aleck [C.] Bond, [who became my deputy here]. There was just a great number of people that were right in that division and a great number of people that were in the Flight Research Division. Primarily the people that ended up in Operations started off in the Flight Research Division. The people that ended up in Engineering started off in the Pilotless Aircraft Research Division.

SLADE: Where did these people come from? Did they get their grounding in World War II?

FAGET: You know, when I joined the NACA in 1946, there was a great number of veterans, World War II veterans like myself. Most of the people that came in[to] the NACA [at that time] were young, very young people who had spent two, three, four years in the war. A great number of them were not married. So we kind of like had a great time back there for three or four years until we all got married. We did a lot of cutting up and stuff like that. But at the same time, having been through the war, I think the experience of the war gave everyone a sense of urgency to get on with the [work] of course, the big thing then was to get into jet-powered airplanes, get into supersonic airplanes and things like that. There was just a great number of very, very important technology development[s] that faced the future [then].

SLADE: Was that the focus of the kind of work you were doing at NACA at that time, you, yourself?

FAGET: The idea was to solve the aerodynamic problems that would allow airplanes to operate at higher speeds and altitudes primarily, and then for the Pilotless Aircraft Research Division, the emphasis moved from airplanes to ballistic missiles, which involved reentry of the warhead [of] the missile, practical solutions to getting the warhead through that [reentry period] on the way down without overheating it and destroying the warhead.

SLADE: And that, of course, had its genesis in the German rocket program that was brought to this country.

FAGET: Yes. There was a great deal of literature that the country acquired from the German Rocket Program. We looked at that and studied it, but pretty much followed our own instincts in how to develop things. I know one of the most interesting papers I read had to do with—toward the end of the war, the Germans had actually put some rockets in airplanes, had rocket-powered airplanes, and they got very concerned about maneuvering these airplanes. They realized that they'd be going right up close to the speed of sound, very fast, and the maneuvers, of course, would entail very high Gs.

[This was] the most interesting research that was available on people being [able] to withstand high Gs, which was a big problem in Mercury, both in launch and in reentry. We were going to push the astronauts up to eight Gs during reentry and almost that high during launch, and then in case [the launch vehicle failed or otherwise had to be shut down at less than orbital speed but above the atmosphere the deceleration would] go much higher than that for sustained periods of time. And they had the initial—well, a lot of papers, the best papers on that [were the ones] they'd done. Incidentally, they did not use prisoners to make that research, near as I could tell. Interesting. Not that it would have made any difference.

SLADE: A good point to make. When during these first four or five years that you were talking about after you came to NACA did the focus switch, in your mind, at least? Because you wrote one of the seminal papers on the single-seat spacecraft shortly after that. When did that switch in your mind? When did you start going beyond the boundaries of space, in your thinking?

FAGET: One of the very nice things that happened to me while I was with Langley is, several years before their X-15 Program took off, the NACA was asked by—[one of] a number of advisory groups, and there was one for high-speed aerodynamics, and they wanted to go faster than Mach Number 3, which is the fastest that we'd [had ever flown]…an airplane. Of course, that turned out to be the birth of the X-15. But preliminary studies were done both at Langley and at Ames Laboratories [Ames Research Center, California] on possible configurations for the X-15.

Now, I got involved in the study at Langley. I was one of, I guess, four key people [headed by John Becker] who had looked at this Of course, we went back to our separate divisions to get a lot more [people involved] in it, but these four people would meet two or three times a week in developing what came out to be the basis of [the Langley]… configuration. Having done the X-15, having that turn out to be successful, because the Air Force was told to build the X-15, and the approach was that NASA would be kind of an advisor to the Air Force in the procurement of the X-15, and then after it was procured, they would share the research with the Air Force and Navy pilots as well as NACA pilots who flew the X-15 after it was turned over to the government.

Well, the next thing that these high-speed flight people [did was advise]… "Well, we ought to have a program that goes beyond X-15 now," and that was called Round Three. The first set of X airplanes got us up to Mach 3 and then the X-15 got us up to six, so the third round would get us to something faster and more or less the minimum objective was to go at least twice as fast as the X-15.

We at Langley were studying that as well as Ames and [other] NACA Laboratories. We had a meeting, and the meeting was set in October of 1957. A couple of weeks before that meeting, the Russians put up their Sputnik. [Laughter] Of course, that set us all back, you know. At that meeting the discussion then was not to try to—maybe we shouldn't try to fly up to those velocities with airplanes, but maybe we ought to bypass the airplane role and go directly into rocketry to get us up to those velocities. We talked about rocketing men up into orbital velocity and how to get them back and so forth.

Harvey [H. Julian] Allen was, of course, a great scientist at Ames Research Laboratory, and he was the one who came out with the blunt body theory. Both the Army and Air Force were having trouble bringing their missile warheads down to ground zero, and he just simply said, "Well, if you make the drag a little higher, you'll get down there. You won't get down as fast, but you'll get down there without burning up." I won't go into all the reasons for this, but what he'd done made an awful lot of sense to me.

So when I got back to Langley and started looking at blunt bodies with at least a couple of my colleagues that are on that paper, Ben [Benjamin J.] Garland [and James J.Buglia]…We did come up in a matter of, oh, I guess three or four weeks, we came up with a pretty good idea of what to do. And then within a couple of months we were able to write that paper [RM L58EO7a]. If you look at that paper, there isn't hardly anything to do [with] capsule design which wasn't predicted in that paper. It was a pretty neat paper. We did a pretty good job of scanning all the possibilities of that thing.

SLADE: I want to ask you a couple of specific questions about that paper a little bit later on, but we're right in an area I want to stick with for just a moment. You came up with an idea for a spacecraft which did you then know that would be Mercury? When did the Mercury concept come into play?

FAGET: Well, the concept we came up with was really a primate for Mercury. [Laughter] It wasn't quite there, but fundamentally it was all there. There's nothing in the Mercury except [the] escape tower that wasn't discussed in that paper.

SLADE: Was the technology within your reach at that time? Did it exist to do the spacecraft at that time?

FAGET: I'll say this. Later on, during the following summer, the summer of 1958, NACA was more or less getting prepared to become NASA. They were more or less told that, "You might get to become NASA around April." NACA formed a group to study the transition, and Bob [Dr. Robert R.] Gilruth at the Langley Research Center put together a team, and Abe Silverstein at Lewis [Research Center, Cleveland, Ohio] put together a team to support this activity. So these two groups would go to Washington [DC] and spend maybe three or four days a week in Washington at our headquarters there in Washington, helping formulate the various programs.

Because I had done this work on the capsule during the winter, the previous winter, they asked me to represent the group on manned space flight. We met with the people in the Pentagon, and I became informed, of course, about all the various programs that the DoD

[U.S. Department of Defense] might be doing, which included programs from the Army, the Navy, and the Air Force. I'll tell you, it became immediately apparent to me that the only practical approach was the one I had proposed, simply because it provided the lightest way to do it, and we were very, very short of big launch vehicles. The Russians had great big launch vehicles. Our best launch vehicle was the Atlas, and the Mercury was the only one that had a chance to be made light enough to be able to make orbit on the Atlas. That was apparent.

And it had some other features that were missing. It's quite obvious now that when you launched a man, you put him in a couch so that the Gs come from his back, and then when he reenters, you turn the vehicle around so the Gs come still from his back, but this was something no one had thought about, how to handle the Gs both during launch and entry. At least they hadn't thought about it very well. I know one of these things, I think it was the Air Force configuration, had studied it enough to decide that, "Yes, we'd better do something about it," so they put the man in a sphere and gimbaled the sphere [inside a blunt-nosed capsule similar to one of their missile warheads] so that the vehicle would always be going in the same direction, and they'd turn the man 180 degrees within the sphere so that he could withstand the Gs during entry. [However]…it was ever so much simpler and the configuration became so much better if you let the blunt end be the rear during the launch, which would decrease the drag on the launch vehicle and have the blunt end be forward during entry, where you wanted the drag.

SLADE: I can imagine how much weight a gimballing sphere would create.

FAGET: Oh, all of these things weighed—you know, people have a tendency to lie about their weights, but they weighed anywhere from fifty percent to sixty percent more and probably would have weighed twice as much if they'd really gotten down to the nitty-gritty.

Now, that was the other aspect of it. At Langley at that time, we did not contract for anything. If we wanted a model built that we were going to test, we had our own shops to build it in. Virtually all the experimental hardware and all of the advanced technology hardware was built right in our own shops. We had another division called the Engineering Division, which supported the researchers by designing the equipment that would be built in the shop.

We had some very good engineers there. Caldwell [C.] Johnson was head of the group that supported the Pilotless Aircraft Research Division. Of course, he came out here with us, Caldwell did. In many ways, Caldwell contributed just as much to the development of Mercury as I did, because he [was] the one that was able to look at the thing and take the concept of the vehicle and turn it into actual hardware which would take the loads and consider all of the nitty-gritty things that made the dream come true.

SLADE: In terms of hardware and operating hardware, basically, did you borrow anything from the X-15 Program? It seems to me quite a lot of the controls were there.

FAGET: Yes. We borrowed one thing that I can put my finger on, and that was, the X-15 Program was designed to leave the atmosphere, and it was designed to fly as high as, I think, more than [250,000] feet, something like that, but aerodynamic shows it wouldn't [be aerodynamically controllable] anywhere above maybe about 130, 140,000 feet. So at those altitudes, it had to have small jets in order to control its attitude. These were hydrogen peroxide jets that the X-15 used, so they already had that technology under development, and we were able to use the same kind of jets, hydrogen peroxide monopropellant jets.

That's the last time that I know of that the NASA ever used hydrogen peroxide. The [safety people] didn't like it because hydrogen peroxide is a little bit unstable, but it was a nice propellant. It's what they call a "green propellant." As for… hydrogen peroxide, after it dissociates [it forms] water and oxygen—and that's next to mother's milk, as you know—it won't poison anyone.

SLADE: Well, I just wondered, because the two vehicles, in some ways, had resonance with each other, and I just wondered how much you had borrowed from the early program into Mercury.

FAGET: Well, that was it. That was just the attitude control system. See, the whole concept was different.

SLADE: Oh, I understand. It was a lifting body aircraft. It was better related to the Shuttle than to Mercury.

FAGET: Yes. As a matter of fact, when we got ready to talk about the next generation aircraft after Mercury, the people at Rockwell—it was North American then—who had just finished developing the X-15, were coming along saying, "Well, you ought to look at the X-15 as a vehicle to go to the moon." And, of course, the X-15 was only able to go Mach 6 without getting aerodynamic heating damage. So it just showed a certain amount of naiveté on the people there that were pushing it. It would have been a big step for the X-15 if it had become the Shuttle. Although I will say this, when we started designing the Shuttle, I wanted to use something that looked a lot more like the X-15 than the Shuttle did, but I would fly it at extremely high angle of attack.

SLADE: We'll get to that a little bit later on.

FAGET: We sure will.

SLADE: I want to talk about that. You mentioned lifting power. In Washington there are apocryphal stories about President [Dwight D.] Eisenhower putting limits on the kinds of rockets that you could use in your early work with Mercury. Was that true, and how did you talk him out of it, if it was?

FAGET: I don't know that Eisenhower had anything to say about it. I don't even think he really cared about it. DoD was developing rockets, and, of course, like I said, we had very cleverly designed a much lighter atomic device—that's what they liked to call them—than the Russians had. So we didn't have to develop big heavy rockets. So we didn't have much rocket power.

To go back to this group that met in the Pentagon, the DoD had just come up with DARPA, and they said that's a DoD agency and they're going to decide what various arms of the DoD, Army, Navy, and Air Force, how they will participate in the space program. So the meetings were with DARPA, who didn't have a vested interest in any particular configuration like the Air Force, Navy, and so forth, and the NACA people were meeting together on this. Quite frankly, it wasn't really clear whether the DoD would be asked to develop the first manned space capsule, whether it was going to be DoD or NASA.

So we both looked at it, you know, like at an arm's-length thing and discussed the various ideas. We not only discussed the configuration of the vehicle that the man would fly in, but also the configuration of the launch vehicle. Both the Army and the Air Force had ballistic missiles at that time. The Navy was just beginning to develop the Polaris ballistic missile, which [used] solid rocket[s].

The people in the Air Force didn't particularly like the Atlas. The Atlas was developed almost totally within the Convair Division in San Diego, as opposed to the Titan, in which case the Air Force and their support group, Ramo Woolridge, had played a pretty strong hand in specifying how the vehicle was built. Now, the Atlas was a [like a] balloon, [it] had an extremely thin stainless steel skin that was only supported by the internal pressure. Incidentally, no one has [since] made a vehicle with as light a mass fraction as the Atlas. It still has the record of being the highest mass fraction approach. But no one likes them because they're stigmatized, [because they would collapse if they lost pressure] you understand.

Well, anyway, so they were trying to figure out how to get enough power to launch these things. The Titan was clearly not far [enough] along in development in order to be competitive in this space race that we'd been anticipating, which left the Air Force with the Thor, which was much smaller than either the Atlas or the Titan. They came in one day and told us they had it all worked out with the Air Force people from the West Coast, BMD [Ballistic Missile Defense], that they were going to develop a fluorine rocket as a second stage to put on top of the Thor. Well, you can imagine how [well] that went over with me, because I said, "Fluorine?"

They said, "Oh, yes. You get a tremendous specific impulse with fluorine."

[Laughter] Can you imagine putting a man on top of a pot full of fluorine? Well, that was what was actually being proposed. Well, that didn't sell. It didn't' sell. But it's kind of an indication of the approach that people were taking. They were looking at every possible way to do things, with not a great deal of concern for practicality as a first blush on these things. The Navy had a capsule that was essentially going to be inflated when it got up into orbit, a big inflatable structure that was essentially a huge delta vehicle—essentially a balloon—with the shape of a high-sweep delta.

The Air Force also had Avco, one of the companies that did things for the Air Force—they were big in the Discoverer [Corona] vehicle, actually—but their approach was to put the man in a spherical capsule and use a stainless steel cloth parachute, deploy the parachute with [adjustable reefing] so he could open and close the parachute and adjust the drag and therefore get it down to the ground. They were talking about opening the parachute.

SLADE: A stainless steel parachute.

FAGET: Stainless steel parachute, which was going to not burn up during entry. There were some wild ideas floating around. It really was a case of the Mercury approach—well, the capsule approach. It wasn't called Mercury at that time. It was the only thing that really had some possibility of being done immediately.

SLADE: How long did it take to come to this meeting of the minds?

FAGET: Well, it didn't take too long. What happened was, NACA had another candidate, which was the one that [Alfred J.] Eggers [Jr.] [proposed], sometimes called "the half-baked potato." [Laughter] But anyway, it was a cone with a spherical nose that was cut in half, and just the lower part of the cone would fly. Of course, a cone with a spherical nose is a stable configuration. If you cut the thing in half along its center line, the bottom half and the top half, and then you separate them and move the center of gravity in the bottom half so that it doesn't change its angle of attack, it ends up having lift. It would have worked. It [really] would have worked. It would have been a lifting body, except that because it was a lifting body, it would end up weighing more because the total amount of heat in the lifting bodies end up having to absorb a lot more heat than something that's purely ballistic, that has a higher drag and no lift and a much shorter exposure to deceleration. But that was, in my opinion, the next most likely thing.

Well, along about the middle of June, maybe the early part of July—I'm vague on the time—the word trickled down that Eisenhower wanted the non-military agency to be in charge of manned space flight. He did not want the military to do this on account of it would look like a provocative move on the part of the United States to essentially make space the [military] high ground. So he just more or less told the Air Force to cool it, "You're not going to have bases on the moon and you're not going to have orbiting vehicles with men in them threatening our enemies." I mean, that was clearly his feeling about it.

So once that was decided, then it had to be decided within NASA which approach to take. [Dr. Hugh L.] Dryden set up a committee to do this and put Bob Gilruth in charge. Well, I guess, Bob Gilruth, you might say that he believed in me a lot more than he believed in Eggers, is about what it amounted to. But we did debate it, and it all got down to the same thing: if you want to do it, the only one of them that's going to manage to get up there and [get into orbit on an Atlas was the configuration proposed in the paper by Faget,Garland and Buglia].

SLADE: And you knew the Atlas was your machine all along?

FAGET: Well, when we first wrote that paper, we did not have access to the secret part of the Atlas Program. We knew some of the basic characteristics, but we didn't think that the Atlas itself would put things in orbit. What we did is, we made it a two-stage vehicle using the upper stage of the Polaris, which was under development.

SLADE: And you were on the committee on the Polaris, too, weren't you? So you were keeping track of that.

FAGET: Yes, I was. I knew a lot more about the Polaris—

SLADE: Which was a solid fuel rocket.

FAGET: Yes, a solid fuel rocket, which made me happy. I was much more comfortable with solid fuel rockets than with the liquid fuel rockets, because liquid fuel rockets were blowing up left and right, you know. So we put the stage of the Polaris on top of the Atlas as a means to get in orbit, which was very nice. It also served as an escape rocket. If the Atlas were to come apart during the early part of flight, then we could always pickle off with the Polaris upper stage.

SLADE: That was your invention of the escape tower.

FAGET: Well, yes. After we got rid of the second stage, Bob Gilruth came in one day and says, "Max," he says, "what are you going to do if the Atlas blows up on the way up?" And I didn't have an answer for that. And he said, "Well, you'd better get an answer for it." I've always said that was an invention on command. [Laughter]

It was very fortunate that one of our colleagues, Woody Blanchard, again in the Pilotless Air Research Division, had been experimenting with tow rockets. He put canted nozzles on a rocket and towed models, research models, up to Mach 1 and above, but instead of pushing, he'd pull them. So knowing that you could do [with] the rocket up front, it was just a small step instead of putting a cable up there, to put a structure up there that would hold it rigidly during launch but be in place whenever you need it. That turned out to be a very successful thing.

SLADE: What did the astronauts say when they saw this thing in operation?

FAGET: I've got a story. Do you want to hear it?

SLADE: I do want to hear all your stories. That's what we're here for.

FAGET: [Laughter] Well, the Mercury Program was handled quite a bit differently than all subsequent programs, primarily in that we did just a tremendous amount of full-scale testing in Mercury, either with [full-scale boilerplate models] or with the hardware itself, and a great number of these tests were just to evaluate the escape rocket. That's why we invented the Little Joe, as you know. And, by the way, Paul [E.] Purser and I shared that invention. It's not patented, but the concept.

Anyway, we had the escape rocket all worked out by the time that this incident happened. It was the first launch of the Mercury vehicle on top of the Redstone [MR-1]. This is the time when the Redstone flew six inches and settled back down on [its launch stool]. Well, that was a very interesting flight. What had happened, they had what we call a relay race, and the abort system, the cut-off system on the Redstone, got triggered before it got disarmed [with a good launch]. The Redstone would sit there while the thrust was being built up, and in case something happened, they wanted to shut it down. Then, of course, after it got off the pad, you didn't want to shut it down in case anything happened. But anyway, the relays that disarm the system hadn't caught up with the fact that it had lifted off, and the Redstone got shut down when the electric power system [umbilical] broke. So it took off and got shut down. Well, the same thing that triggered the liftoff on the Redstone also started the clock going in Project Mercury up in the Mercury capsule.

SLADE: Which was unmanned, of course, we should point out to the researcher.

FAGET: This was an unmanned test. There was nobody in it. The idea was to fly the thing up to a stated altitude and then—and, of course, on the way up, at a certain altitude you get rid of the escape rocket. So the timer started running on Mercury, and the escape rocket went off without the capsule, you know, just lifted off and left the capsule.

This was one of the very early flights, and the Army was not near as bureaucratic as the Air Force was about safety. They had a little blockhouse there, and the Redstone was sitting on a pad, and people would go, you know, maybe four or five hundred yards away from the pad and hide behind a sand dune until it took off. Well, I was back of the sand dune, and [M.] Scott Carpenter, [L. Gordon] Cooper [Jr.] and [Virgil I. "Gus"] Grissom were back of the thing with me. Cooper and Scott—we were watching this thing, you know, and they knew what the escape rocket was for, and all of a sudden this damned escape rocket—we didn't know what was going on, except that the thing fired and then stopped firing, and the escape rocket went off. [Laughter] Of course, just the escape rocket itself. When the escape rocket with the capsule on it would leave at eighteen Gs, it really was a thing, but the escape rocket all by itself would leave around forty Gs, maybe forty-five Gs, about three times as fast. [Laughter]

That thing just took off like that, and Carpenter said, "Wow!" He could see himself riding that thing, you see. [Laughter] I don't think that any of them looked forward to riding the escape rocket. They did have the so-called "chicken switch" in there.

SLADE: They're interesting guys.

FAGET: Yes, they were. Of course, then, after that, it went through the whole business of undressing itself. The parachute came out and lay on the side and everything else. [Laughter] Everybody thought that the capsule had made another blunder when really it was the Redstone.

Talking about escape rockets, you know the Russians use an escape rocket, and they saved a crew of two. About a year and a half ago, the Russians were here for a visit, and the head of the Russian astronauts, sort of like Deke [Donald K.] Slayton was, anyway, I got to meet him. It often bothered me that they do this escape rocket which is just a takeoff on what I'd invented. [Laughter] So I told him, I said, "You know," I said, "I invented the escape rocket, and you guys saved a crew that way, and I never got a Red Star Medal for that."

SLADE: Were you promised one?

FAGET: I was teasing him, you know. He had an interpreter, and I could see them talking back and forth. He'd been autographing things for people, so I had a little card that he'd autograph. He had the guy write something on the card, then he signed it and he handed it to me. It said, "I owe you one space medal." [Laughter] Well, they ended up giving me a medal and a little ceremony, and it wasn't the Red Star, it was just some medal that somebody had, I think.

But it turned out that the two cosmonauts were both in Houston at the same time, both on different programs, but they were both there. Friends and so forth got together, and they arranged for these guys to give me this little medal. So I got a chance to talk to these two guys, and I asked one of them, the senior guy that did all the talking and could speak English pretty well, I said, "When that escape rocket went off—" I've got to explain to you that that was kind of a very close call. Something happened on the pad and there was a fire on the pad. Apparently some of the kerosene had spilled or something like that and caught fire, and the whole bottom of the pad was burning. The people in the blockhouse sent an abort signal by radio, and it didn't get through, so they sent it by hard wire, and fortunately the hard wire was still there, but the escape rocket went off just about a second or so before the whole damned thing blew up. [Laughter]

SLADE: Right on the pad?

FAGET: Right on the pad. See, it was burning, and finally it is going to blow up. Something was going to melt, and the whole thing will spill over, and there'll be a big explosion.

So I asked him, I said, "Tell me about the experience. How did that feel?"

He said, "Well, we were up there, you know, in the Soyuz waiting for the launch to go down, and all of a sudden it started shaking, and I said to myself, 'Something's going to happen.' Next thing I knew, I was 2,000 meters up in the air." [Laughter]

SLADE: That must have been a real kick.

FAGET: Oh, yes. He said he got up there so fast, he was surprised. [Laughter]

SLADE: Did he have any physical effects from this ride?

FAGET: No. He's perfectly all right. Gee, I wish I could remember that general's name, the Russian general. But he was telling me about it. He said, "You know," he said, "that thing worked perfectly." And he said, "You know what? We never tested it." He was proud of the fact that they hadn't tested it! He said it worked perfectly. [Laughter]

SLADE: Until he came along they never tested it, anyway. [Laughter]

Well, let's get back and wrap up Mercury and put it on the record. The paper that we began this discussion talking about, that laid the foundation, read this way—and correct me where I'm wrong—at Langley your group came up with a technical note, "Preliminary studies of manned satellites, wingless configurations, nonlifting," in which your group wrote that, "Because of experience with ballistic missile programs, there is a minimum requirement for an autopilot guidance or control equipment." You also stated that, "Only one real maneuver is required of such a satellite or spacecraft, the retrograde or braking maneuver." You continued, "Once this maneuver is completed—and from a safety standpoint alone it need not be done with a great deal of precision—the vehicle will enter the Earth's atmosphere and noting that the inherent stability and structural integrity of the vehicle are things of a passing nature."

When they read this paper, I'm wondering, and you had such close association particularly with the original seven astronauts in those days, how did all of that sit with the astronauts who considered themselves first and foremost pilots? Did they find anything to give them pause in that?

FAGET: You know, the test pilots—the idea was to recruit test pilots for this job, and the test pilots didn't like it. I'm talking about the whole body of test pilots. These guys thought here was a chance to get in space, you know.

SLADE: These seven.

FAGET: They went in for adventure, but, by and large, the test pilots said, "All we are is a guinea pig. I'm not going to volunteer fosr that program." Many of them felt that way, but these guys insisted on getting as much control of the vehicle as possible throughout, and we did give them quite a bit of control. The thing would work without them, no doubt about it, and I to this day said that's the way to do it, of course, because we didn't know what they'd do when they got up there, how they'd react and all that. They might end up vomiting and choking on their vomit, or whatever, you know. So we wanted it to be able to work automatically. So it was going to work automatically. I never heard any of them disagree with it very much. There were some things they didn't like. Of course they didn't like the fact that we didn't have a window for them in the front, so we put a window in the front. And a few things like that.

The performance of the Atlas kept growing. When we first laid out the design, it was very important that we keep the weight under 2,000 pounds. By the time we actually flew the thing, it was something like 2,600 or 2,700 pounds.

SLADE: The Mercury capsule?

FAGET: Yes.

SLADE: Was that with the tower or without?

FAGET: I think I'm talking about on-orbit weight. I'm pretty sure that that's the case. Oh, no, the tower wasn't included. The luxury of a window in front was not there in the beginning simply because we couldn't afford the weight.

SLADE: Did they give you much grief about that?

FAGET: Oh, there was a big beef about that. We had two little portholes about that big around, six-inch round quartz windows, one down here and one over here, and it wasn't very good. And another thing we had is, in order to navigate, we had essentially—it was like a periscope, only actually it was optics to show them a virtual image here of the ground passing underneath them. We thought that was very important, that they see the ground so they could line it up with a radical in there to make sure the vehicle wasn't yawed. If they could see a piece of ground going right down along the center line, well, they knew that they were headed right so when they fired the retro[rocket] off, they would be properly aligned. Actually, the [attitude] could be misaligned some fifteen or twenty degrees and it wouldn't make that much difference. It would move the landing point further down range, but that's about all. We had more than enough capacity [to retrieve the capsule].

SLADE: Of course, that meant moving ships in order to—

FAGET: Well, we had ships. We had ships strung out all over the ocean. [Laughter] The recovery system was—

SLADE: What happened to Scott Carpenter that he went so far down range on his ride?

FAGET: Well, in the case of Carpenter, he used up all his attitude-control propellant before it came time to fire the retrorocket. There was just a little bit left. Well, he didn't have very good control of the attitude, and, as a consequence, he did land far down range.

SLADE: Did he do this playing with the spacecraft? Is that how he did it?

FAGET: As I understand it, he was using the attitude control system to look at the ground, and he'd want to look over here, so he'd roll over there. So he was just looking around, stargazing. [Laughter] Carpenter was more of a poet than a good test pilot, there's no doubt about it.

SLADE: Who among them did you like the most?

FAGET: I liked Scott. Deke was always easy to like. Wally [Walter M.] Schirra [Jr.] was a lot of fun. John [H.] Glenn [Jr.] was all business, as was [Alan B.] Shepard [Jr.]. They were both all business. The others were—

SLADE: Gus Grissom was a taciturn sort of fellow, wasn't he?

FAGET: Oh, yes. Yes, he was. I know that Wally—you know, they moved out there in Virginia and lived close to the water, and Wally Schirra had an outboard motor, and he taught me how to water ski. [Laughter] I remember that well.

SLADE: Those were great and exciting days.

FAGET: He was a good friend of Deke's at the time. Me and Deke were water skiing.

SLADE: They all had specific assignments in helping develop—how much did they really contribute to the development of the system?

FAGET: Well, they didn't do an awful lot. I mean, it was pretty much decided ahead of time. I mean, they contributed things like making sure they got that window up there and a few things like that. [Laughter] You know, the idea was to make them part of the program so that they'd improve their confidence in everything, which they did. I mean, it worked out very good from that standpoint.

SLADE: One of the experiences during that early program captured you the most. I assume John Glenn's flight was a high point for you, but you had two ballistic flights before that. What was the greatest triumph, in your mind?

FAGET: Actually, one of the test flights was the biggest one for me. The first time we put it on an Atlas, it wasn't supposed to go in orbit, it was just supposed to go down range and reenter the atmosphere at what was probably the worst condition, which was around 20 to 22,000 feet a second. I forget what it was, something like that. This was our first Big Joe. It was a boilerplate capsule, which meant it was built in our shop. It had the right weight and all, but the weight went into the structure instead of a lot of internal equipment.

It was really a test to find out if the heat shield would work, primarily. It had an attitude-control system on it which was rather weak. It was high-pressure gas, cold gas, going through some jets, and it went on an early Atlas. What happened was, the Atlas failed to stage. The Atlas has got three motors on it, two big ones that drop off at about halfway up there, maybe. They shut those motors down, they drop off, and then just the center motor is running, and getting rid of all that weight gives it all this extra performance. Well, this particular Atlas shut down those extra two motors, but they failed to jettison, and that was quite a bit of extra weight on there. So it never got to the speed that would cut the engines off. It never got to what we call MECO, Main Engine Cut-Off.

So it kept trying to go faster, and, of course, it ran out of propellant, but it didn't run out of gas. There was still high-pressure gas in the tanks that would push the propellant through. So the gas was coming out the nozzle, so it was still thrusting. It wasn't thrusting with rocket [propellant]; it was thrusting with high-pressure gas. Of course, when it hit MECO, it was supposed to separate the capsule and back off from the capsule, which it never did. It never got to MECO, so it never fired its separation rockets.

We had a back-up timer on Mercury in case it didn't get a signal, so the back-up timer would pop the connection, which was a clamp band that held the capsule onto the Atlas. That got opened up. Then it was supposed to turn 180 degrees because it changes attitude for reentry, going from the launch attitude back to the reentry attitude. But because the Atlas was still thrusting lightly, although it was thrusting, it never got out of its seat on the front end of the Atlas, and it used up all its propellant trying to rotate the whole Atlas. [Laughter] Of course, it had no attitude control system at all then.

We had one instrument in there—we had recorded information in there, and one of the things that we were curious about, not really concerned, just curious about, would be the noise level inside the capsule during this flight of the Atlas, realizing that it was kind of a dirty situation, what with the escape rocket and all this other stuff on there, kind of dirty on the way up, and it was probably pretty noisy, you know. The aerodynamic noise was probably pretty high. So we put a microphone on there and a tape recorder, just a simple thing.

Well, of course, it didn't land anywhere near where we had all the fleet waiting for it, so they sent some airplanes out there, and everybody thought that it probably burned up or something like that, but, no, it didn't burn up. It survived. It came in at a big angle of attack. The reason we know that, you could hear this microphone. It would go "Rmmmm, rmmmm." It got louder and louder as it went back and forth, and then, of course, the frequency increased. As the aerodynamic load on it increased, of course, it got stiffer, aerodynamically stiffer, going "rumm-rumm-rumm-rumm-rumm" towards the end. And it got a little bit of burning on the back, because it must have entered at a very high angle, but it survived. And that was the one thing we wanted to make sure, that if something didn't work, if the attitude control system didn't work, just the retrorockets would work, the son of a bitch would come in and get everybody home.

We didn't ask for this test. That was free. Everybody thought it was a terrible failure, but I said, no, it's not a failure, it's the best damned test we could have had. It survived the worst conditions you could imagine for reentry. That was the first flight that we ever made with the configuration full scale.

SLADE: Your baby came home.

FAGET: Yes, it came home. Came home.

SLADE: You had the chimp flights, then you had two suborbital missions which were not on the Atlas. Those had to be big moments, too. But I've got to agree with you, seeing that this thing was going to carry humans, had come through that kind of a ride and survived, that must have been a big moment.

FAGET: That was a great moment. Of course, the exciting part was that we didn't know where it was for about five or six hours. Finally, one of the ships we had picked up a radio signal, a beeping that we'd put on. Then they sent back a message that they had eye contact. Of course, by that time then we had destroyers go out there and pick it up, but they had to go, I don't know, 700 miles, the destroyer that picked it up, so it was a number of hours before we got it back.

SLADE: You only lost one spacecraft in that series, the one that Grissom was aboard. What happened there?

FAGET: Well, that was one of those kind of things that they—again, make the thing as loud as we possibly could. The hatch that they went into was fastened with something like about fifty or sixty small bolts, so it really wasn't a hatch, it was just a covering. So they were essentially sealed in the capsule.

SLADE: Were those explosive bolts?

FAGET: No. The original configuration. What happened was, the upper part of that capsule held the parachutes. There were two parachutes, the main parachute and the back-up, which were identical, completely identical. Even the systems were all identical. They had their own drogue parachutes and pilot parachutes and everything else, but we never had to use the back-up system. And there was a hatch up in front, up at the top. If you were sitting in the capsule on the pad—of course, it's a cone around you like that—right up there would be this hatch, and that was nothing but a dish that was held in place, more or less, by the pressure, although it had a few latches , an inwardly opening door, which made it very light, and, of course, it was dish-shaped, so that it was just about as light as you could make it.

So when the thing got on the water and floating upright, you could unfasten this dish and push the containers for the parachute, just push them out, they'd fall overboard, and you could get out. As a matter of fact, [during] Scott Carpenter's flight, because he fiddled around with the attitude control system unnecessarily, he landed several hundred miles from where he was intended to land, so he had to wait a number of hours. He'd gone through his whole return. He was sitting up on the top of the capsule waiting for them to come pick him when they showed up. So that part worked.

Well, the astronauts did not like the idea of being trapped in this thing, so they complained about it, and we put this explosive bolt device on the side there, which had to be on and then fired. Apparently Gus must have armed the thing and then hit it with his elbow, and it fired. I'm pretty sure he armed it.

SLADE: And the water started coming in.

FAGET: He won't admit that he armed it, but he armed it, I'm pretty sure, and apparently he hit it with his elbow and it went out. He might not have remembered arming it, to tell the truth. There's no reasonable way that that thing would have taken off and fired by itself.

SLADE: You only had one other incident during the Mercury Program that must have made your blood pressure go up pretty high, is with the retropack on John Glenn's flight. Tell me about that.

FAGET: Well, this is one thing that I'm kind of proud of, in a way. We considered all possible kinds of failures, and one of the failures that we considered was that the retropack would not jettison. The retropack sat on the heat shield, and it was held…by three straps. I thought, well, maybe the damned thing wouldn't get jettisoned for some reason. So we ran some wind tunnel tests with the retropacks on there. We found out it was stable with the retrorockets on there. So we had these sensors, and the sensors were designed so that if any one sensor said that they had not been opened, it would let you know that. Any sensor that opened would let you know it had been done.

Apparently we had a bad sensor on that flight, and we thought that the heat shield had been released. Well, the arrangement was such that if the heat shield were released, the straps would have still held it on. So everybody was concerned that the heat shield had been released, because that's what the instrumentation said. Well, they called me up—I was back in Houston—and asked me what about it, and I said, "Well, you can enter that way because we've got wind tunnel data that said the thing will be stable," and they did.

SLADE: You must have been the calmest man in NASA that day if that's the case. [Laughter]

FAGET: Well, no, I told them that we had a wind tunnel data. Well, that's right. [Laughter] That's right. They knew about this failure for, I'm sure, quite a bit of time before they ended up calling me up. They were all trying to figure out what to do about it, and somebody said, "Well, why don't you just leave the retrorockets on there instead of jettisoning." They said, "Well, we don't know if that would work." So they called me up to find out if that would work. I said, "Yes. That would work. You've got wind tunnel data that says it will work."

So they told John to leave the thing on. Of course, that's when he found out what was going on, you know. I talked to him. He said, yes, it was quite a display of these pieces that came flying by, burning up.

SLADE: We have a senator [Senator John Glenn] today to prove that it works. [Laughter]

FAGET: Right. [Laughter]

SLADE: I guess it comes down to that.

FAGET: Yes.

SLADE: Why don't we take a little break, and then we'll get on to Gemini and Apollo. [Brief Interruption]

SLADE: Dr. Faget, in 1962—and correct me if my dates are wrong—but I believe in 1962 you were named Director of Engineering and Development at Manned Spacecraft Center, Houston. How did your day-to-day role change then, or did it?

FAGET: Well, it didn't really change. It was pretty much the same thing. The thing that [was important], had to do with the move, as opposed to the change in title. We came to Houston. We had to build a center. All of the engineering facilities, they all had to be specified, worked out, negotiated, and an organization had to be built up. It was a pretty yeasty time.

We went from essentially a one-man project, [Mercury] a one-program project, to really trying to do three things at the same time, three programs at once plus build up the center.

SLADE: You were trying to telescope three levels of thinking, weren't you—I mean, Mercury, Gemini, and Apollo. You were trying to do all this at once. Was that at different levels?

FAGET: As far as Mercury was concerned, that was out of Engineering. We didn't have virtually anything to do with it other than saying, "Yes, it's all right to fire, to leave the retrorockets on," was about as much engineering as I did then.

And Gemini really didn't require an awful lot. There was a few new things on Gemini. There were the fuel cells [along with their cryogenic oxygen and hydrogen storage systems. Also, Gemini was designed to be able to make significant translation manuevers which required the use of a much more powerful auxiliary propulsion system. This was all carried in the adapter section which stayed attached to the capsule until reentry. Gemini also had an offset center of mass to provide a small lift vector so that it was able to maneuver during entry to minimize splashdown dispersion. You know that Gemini was primarily the result of Bob Gilruth insisting with NASA Headquarters that it was essential to have more experience in space operations before we tried flying to the moon. I'm convinced we would never been able too make the landing in Kennedy's decade without the training and operations development that Gemini provided].

SLADE: There was also an environmental control system and eventually a computer system.

FAGET: Environmental control system, yes. And then Gemini had a small computer in it to do the entry.

SLADE: Jim [James A.] McDivitt said that he wished he had an abacus on the first one.

FAGET: [Laughter] Well, Apollo was the big driver as far as engineering was concerned. We had to get that going with Apollo, get that thing under way. No doubt about it. We just selected the program for Apollo and had to go with it.

SLADE: And you were using Gemini as a testbed for so many of the particulars of Apollo, weren't you, the rendezvous and docking, the maneuverability of the spacecraft?

FAGET: Rendezvous, docking, extravehicular activity. But that came about after it got to flying, doing that. Primarily the focus of modularization was still primarily on Apollo. We were going through all the business of going from a single vehicle to a two-vehicle system and had to come up with the specifications for the LM [Lunar Module] and do the whole procurement bit. That was a big effort. We'd actually, of course, done the procurement for the command service module while we were still in the [beginning of] Gemini.

SLADE: Oh, really. That far back? That would have been 1961?

FAGET: Yes.

SLADE: So you were all setting into that program that early on. I mean, the design stage that early on?

FAGET: That's right.

SLADE: How were you doing that?

FAGET: We actually started looking at lunar flight, I guess, six or eight months after the birth of NASA. I remember Washington [DC] was trying to look at the future, you know, and understand what was going on. Well, one of the first things [Dr. T. Keith Glennan] did was he created this group under Bob Gilruth to do the manned program. He put Bob Gilruth in charge of the manned space flight. We didn't call it Mercury at that time. We still called it "the capsule." [Laughter]

So Bob had a couple of meetings, and then he went in and reported to Glennan. So NASA must have been about two or three weeks old. He told him where we were, that we'd selected this capsule shape and we were going to do this and we were going to do that. Finally, Glennan said, "Well, that's fine. That's fine," he says. "Now what do you want me to do, Bob?"

Bob said, "Well, I think I want you to tell me to go ahead."

So he said, "All right. Go ahead. Do it."

So [Bob] goes back, and he talked to the head of Langley, Tommy [Floyd L.] Thompson, and he said, "You know, that guy told me to go ahead, but he didn't tell me how. I haven't got any organization. I don't know how I'm supposed to do this. He told me to go ahead."

They got their heads together, and Thompson said, "Well, why don't we just create the Space Task Group," so Tommy Thompson created the Space Task Group within Langley to do this job and put Bob Gilruth in charge of it.

SLADE: And out of that [unclear].

FAGET: Yes. And then they got together, and they named [thirty five people]…by letter that Tommy Thompson signed, that created the whole thing.

SLADE: And you had this capsule in the wings waiting to go.

FAGET: Oh, yes. We knew what we were going to do. We [really] knew what we were going to do. We just wanted some authority to do it. We knew who was working on it at that time. It was not hard to pick out the people. He asked Bob, and Bob asked me and got all the names on a piece of paper, and he wrote this thing, this famous letter that—you know, thirty-five original plankowners, or whatever you want to call them, and created the thing.

Then Glennan had a system where he'd have a meeting every month where different people would talk about programs that were being started, the various programs that were being started. I was asked to tell them how we might go to the moon, I mean, how we might end up, [with] what would be a lunar program. This was strictly right off the wall at this time, just actual ideas on how to do this.

So I spent a couple of hours before I went to Washington that time, thinking about it, and I got up and said, "Well, the first thing you'd do is you'd fly around the moon," and told them how much velocity that would take and all that, made the typical figure-eight drawing, you know. You'd just go out there, fly by, and you'd come on back, and we wouldn't go very close to the moon. We didn't know exactly what the gravity number of the moon was. If you didn't go too close, the chances of getting a pretty good trajectory without too many corrections would be all right. Then the next time we'd fly closer, and then the next time we would put it into an orbit, albeit a very high orbit, and fly back after we looked at the moon. Then next time we'd lower the orbit. This is typical of the way you [flight test]…an airplane. First you taxi it, then you take off, and you maybe go up to 4 or 5,000 feet, you fly around the airport a couple of times.

SLADE: With the wheels down.

FAGET: And then you go faster and higher and faster and higher. Well, you know, here what we're doing is describing a program where we approach the moon rather cautiously, each time getting a little closer, and finally, after you'd made several missions orbiting the moon, then you'd think about landing. You'd have all the good landing sites picked out and so forth and so on, and then you would descend from orbit and make a landing.

I got finished doing that, and the guy that was head of JPL—what was his name? Bill [Dr. William H. Pickering]. Anyway, he said, "Max," he says, "you know, we're just now working on the early stages of Surveyor, and in the case of Surveyor, we're going to go right at the moon, go straight in and make a landing." He said, "This is much more straightforward. Why wouldn't you want to use that approach, being as [we would have] already done it a number of times? Why wouldn't you want to do that?" You know what the Surveyor does. It comes screaming in at the moon at something like about 9,000 feet a second, and when you get about twenty miles high, they turn on the rockets and slow down. Hopefully, they get it all slowed down by the time they get to the surface. But if you slow down too high, you use up all your propellant, then you don't have enough to land with. If you slow down too late, you hit the moon before you slow down enough.

All of that was going through my mind like a fast forward on [the VCR], and I didn't know what to say. [Laughter] So I finally said, "Well, I think we'll think about that, but I don't really think that's going to work too good."

SLADE: That was William Pickering, right?

FAGET: And [Werner] Von Braun picked right up, and he defended it, said, "Yes, maybe we ought to think about doing it that way." But, see, no one had really thought about how would you land a man on the moon, except perhaps I thought about it three or four hours ahead of time. I think anybody else who had thought about it long enough would have come up with a totally practical way to do it.

But anyway, of course, when [Alan B.] Shepard [Jr.] flew and the President [John F. Kennedy] said we're going to go to the moon and threw down the challenge, we left out a lot of those [build-up missions]. So that would have been the way we'd have done it, you know, [cautiously. But such caution became an unaffordable luxury].

SLADE: Did you envision anything of the mammoth size of the Saturn V when you were doing that few hours of thinking about how to get there?

FAGET: Had no idea what size rocket it would take. I did know that they were talking about making a very large rocket motor. At that time, of course, Von Braun was still in the Army. He was still part of the Army. Both the Army and the Air Force were looking at bigger rockets. The Air Force, of course, wanted to put a base on the moon. [Laughter]

SLADE: Not such a bad idea now.

FAGET: Well, not what they had in mind. [Laughter]

SLADE: You say that you were basically most interested in Apollo when you came over to Houston. How much input did you have in the Gemini spacecraft?

FAGET: The Gemini spacecraft was—

SLADE: Was it just an extrapolation of Mercury?

FAGET: It was really an extrapolation of Mercury. It was not competed. What happened was, a man named Jim [James A.] Chamberlin came in. He's the guy from Canada, from AVRO, and he brought a bunch of Canadian engineers with him, which was really a godsend, because that put some real experience into the group. Bob Gilruth put him in charge of the day-to-day management of the Mercury Program. He created an organization and put me in charge of what amounted to engineering, although it was a different title, but it was essentially doing the same thing I ended up doing.

But he and the people at McDonnell…were looking at all of the shortcomings of Mercury, because, as you pointed out, Mercury was not a vehicle that was controlled by people, by the occupants. Mercury was a vehicle that just went up and came back down. It didn't do anything except stay in orbit until it was time to come down. They recognized that they wanted to do more than that, so they conceived of this program.

When Bob Gilruth told me about it, I said, "Well, they ought to have at least two people in there." That was my contribution: "They ought to have two people in there," so they made it bigger and put two people in there.

It's kind of interesting, Jim Chamberlin was really kind of the—well, he was the force behind the Gemini Program. There's just no doubt about it. But Gilruth liked the idea of two people. He told McDonnell that they ought to have two people in there. Jim was the last one to find out we'd decided to put two people in there. [Laughter] But he thought it was a great idea, too. So we had enough to do. Titan was going to be big enough to carry two people.

SLADE: I have a question. That spacecraft was built by the same manufacturer as Mercury, yet Gemini did not use your escape tower. Why was that? Because of the Titan?

FAGET: No.

SLADE: Yet Apollo did use your escape tower.

FAGET: Yes. Well, that was somewhat of an aberration, and I argued long and strong against what they did, but they did it anyway. Gemini was going to make a landing using a gliding parachute in the original concept, use a gliding parachute, and they wanted to put ejection seats in it. In the event that something went wrong with the gliding parachute, instead of having a back-up parachute, they'd just eject. So they had the thing designed with ejection seats in it from the beginning. They said, "Well, we've got ejection seats. We don't need to put the escape tower on there." And there was a little bit of rationale there. The fact that they were using hypergolic propellant meant that the fireball would not be near as big. Now, you might say, "Gee, you're going to use hypergolic propellant where you just touch it and it's going to go off and you've going to have a smaller fireball?" Yes, that's the case.

The thing about liquid oxygen and kerosene is that they can mix quite a bit before they go off. You can't mix hypergolic propellants. The minute they start to mix, they go off, and for that reason they'd blow each other apart, and the amount that ends up getting involved in the fireball is very small. You can see if the tank were to spring a big leak or an opening, the propellants could mix quite a bit and then go off. Of course, then you'd have a really big explosion. So that was the thought.

But the bad part about the ejection seats, they probably would not have worked much over about 20,000 feet of altitude just simply because the velocity would have been too high. If you had to eject very quickly while the rocket was still firing in the back, for some reason or another, you're liable to go right through the fire from the rockets. The best thing about Gemini was that they never had to make an escape.

SLADE: I'm sorry. I messed up your line. That's a great line.

FAGET: Chris [Kraft] will tell you the same thing. If you ask him what he thinks about the ejection seats, he'll say, "I'm glad we never used them." [Laughter]

SLADE: It seems to me that ejection on the pad with an impending explosion would probably have killed the astronauts. Or am I figuring that wrong? Because it would have been a lateral ejection.

FAGET: The ejection on the pad would have been quite marginal, no doubt about that. It seemed like, yes, the parachute would open, and the man would maybe make two swings on the parachute before his feet were on the ground. Well, I don't know. You know, thank God we never did that. When Wally [Walter M.] Schirra [Jr.] faced the elephant, so to speak [on Gemini VI-A], he did not eject. [Laughter]

SLADE: That's when the engine shut down.

FAGET: Yes. That's when the engine shut down. It was a close one. It was a very close call.

SLADE: He had a cool head.

FAGET: Yes.

SLADE: Well, moving on—

FAGET: I'll tell you, the whole idea of Gemini was probably Bob Gilruth's idea more than anything else, and there's no doubt at all that we would never, never have done the Apollo Program in that decade without the Gemini Program, simply because when we finally got

Apollo developed, we had very little [time left]…to do mission operations. It had all been worked out using the experience in Gemini and using the procedures, and the whole protocol of how to operate was developed during the Gemini period, and it couldn't have been done with the Mercury capsule. They had to have something that was maneuverable, that would do things, and so forth, like the rendezvous.

The rendezvous was particularly important, but also the experience with extravehicular activity was very important from an engineering standpoint. By the way, all of the spacesuits were developed as GFE [Government Furnished Equipment], not made part of the contract, so we had separate contracts directly with the people that made the suits, and a lot of the technology was developed in our laboratories on the suits.

SLADE: Earlier you touched on that fact, that at Langley you virtually invented and developed everything you needed and then—

FAGET: Right.

SLADE: When you came over here, and you got into these deeper programs, it became a contractor relationship. Was that satisfactory?

FAGET: We fought it as well as we could. During the early stages of Mercury and Gemini, we had back-up programs. Well, when we went into Apollo, save for the people at McDonnell…who were completely involved with Gemini, our people were the only ones who had any experience at all with space flight. All of our contractors had never been involved. So they made choices and all that in the various systems they put in there, and we would grade them on their choices. The fact is, we would dictate some of their choices. You made mention of the fact that we specify hypergolic propellants as opposed to using cryogenic propellants—I mean oxygen, liquid oxygen. You didn't want to use liquid oxygen on account of propellant handling is so much more complex, and we were trying to keep things simple so that we had great confidence that the developments would be reliable. You only can get reliability—simplicity and reliability go together like— [Laughter] So, those sorts of things we specified. But even so, we would run back-up programs within our laboratories on a lot of things, and in many cases, when it came to a dead end, we had the back-up program that we could step in and use.

SLADE: The Apollo design, was that an outgrowth of the two previous programs? It seems to me you started early enough that you almost had to start from ground zero on Apollo.

FAGET: What we did was, long before the President made his announcement, we had three funded studies on a lunar program that Bob [Robert O.] Piland, another man from the Pilotless Aircraft Research Division, Bob Piland was in charge of those studies, and they ran concurrently. Three different contractors doing three parallel studies looking at vehicles they could use to go to the moon. Interestingly enough, they all ended up with different kinds of capsules that they would go to the moon with.

After we looked at them all, we said, "Gosh, there's nothing wrong with a plain conical capsule with an escape rocket on the front of it. That works pretty good, so we're going to stick with that."

SLADE: Max Faget spoke again. [Laughter]

FAGET: Well, I left that decision up to Bob. Bob was running the program, and he just came in and told me that we'd better stick with the basic shape. We ran our own in-house study at the same time the contract was [underway], and everybody was trying to invent, explore different ways of doing things right along. Apollo turned out to be a good spacecraft.

SLADE: The two-vehicle concept, how did that come about?

FAGET: Well, there are two stories on that. There's the one that you'll hear from Bob [Robert C.] Seamans [Jr.] and John [C.] Houbolt …at Langley. What happened was, we started off with the idea it would be an all-out launch, that we'd launch a vehicle that would go to the moon, land on the moon, come back. We kept running the numbers through, and the numbers always came out to something that would require like eight engines instead of five engines on the first stage, which [was the largest] we could [get Marshall to commit to]. We had to have an oversized vehicle. Every attempt we made to get it smaller, we couldn't fit it in, and that included using liquid hydrogen and liquid oxygen in the descent stage to land on the moon. We'd still have the return hypergolics, you know. With cryogenic fuel on the moon for any extended period of time, you're going to boil away all your cryogenics. That's one of the big things against it.

There are lots of stories that go along there. John Houbolt of course, recommended that we use a rendezvous at the moon, and he came up with some numbers, that what he was trying to do was show how small it was. His LM, which would carry one man down to the surface, was like 3 or 4,000 pounds. Well, as it turned out, he was off by a factor of [almost] ten. Of course, we carried two people. But the basic idea of rendezvousing at the moon took a little while to sink in, and we had to look at it very seriously before we bought it, but the choices were not good. No one wanted to do rendezvous at the moon, simply on the basis that that's a pretty ticklish maneuver [when you consider the primitive stage that maneuver was in on Earth with tracking data and all]. You [wouldn't]…have very much control of it [at lunar distance].

But things started falling in place. The tracking capability improved. Another thing that happened was that we had a choice between a very large rocket plus a cryogenic landing stage, or a rendezvous in Earth orbit, with several [launches] making up the package that could bring this very big thing out to the moon, or else a moon rendezvous.

We were also encountering problems with the design of the landing thing. We first thought we'd just have a stage of it land on the moon, and it would be sent to the moon. This stage, with the capsule in front of it, would just land on the moon. But when you did that, the part the people were in would be way up high, very high, because it had this whole big stage on it, and although it was a high [specific] impulse stage, the propellants were low density, so it was huge. It had to be huge to carry all that propellant, and that didn't seem satisfactory at all. Furthermore, it was hard to put the man in a position where he could see very well. We actually had something that looked like a front porch that we put on the side of the capsule that the guy could crawl out in, and that would be jettisoned before entry. That didn't sound very good.

Then another thing, an interesting thing, happened from an internal politics standpoint. About that time [James] Webb came in [to] replace the head of NASA. [He then replaced] the head of Manned Space Flight up in NASA [Headquarters], which was [Abe] Silverstein. Silverstein had been made head of Manned Space Flight, so he had his hand in everything. [Frankly, he was a big nuisance to us.] So they told him, "We're going to get somebody that's used to running big programs to run this program." I think he didn't particularly like that. In order to soften the blow, they said, "Well, we'll put you in charge of the Lewis Laboratory." And he said, "Okay, but I want to do part of this program." So they gave him the landing stage.

So instead of having just the people in Huntsville [Marshall Space Flight Center] to deal with, we were going to have to deal with the people at Lewis as well in order to get our capsule on the moon. I didn't like that, to be perfectly honest with you. I felt like, boy, this is going to be a very difficult program to run. We're going to interface with not one, but two different groups, and without a clean separation of where one program ends and another one begins.

But in order to make it reasonable, [we] came up with a pretty good idea, which we called the Lunar Crasher. Instead of having this rocket that would land on the moon being all cryogenic, we put another little stage between it and—we would use this thing to get us down to maybe 4 or 500 feet per second velocity over the lunar surface, and then we'd separate from it and land with a [much smaller] stage that used hypergolic propellant and could be…throttle-able. We liked that hypergolic propellant, and we liked the idea of using something that you could make throttle-able a lot easier than a brand-new rocket engine, a big rocket engine. We had to cut it down to size, cut the landing stage down to the job of just going from 400 feet a second along the surface, to stopping and hovering and landing…[Then by giving Lewis the crasher stage we]…kind of held off Silverstein's role as being so intimately related to our job. His dominant personality wouldn't help… Interfacing between organizations is much more difficult than interfacing between various parts of the mechanical interfaces. I'm confessing now my inner nasty thoughts. [Laughter]

SLADE: I'm listening to every word. Go ahead.

FAGET: So the complexity of all this kept making the lunar module look more and more attractive. So we finally gave it a good hard look and [found it] solved all our problems. Not only did it solve the problem of being able to get there with one launch of the Saturn, which was very important, which Houbolt was selling, of course, but it solved problems that we didn't think about before. It made one spacecraft that would be nothing but a space flight, and we wouldn't have to operate [except] in space. The LM didn't have to have any heat protection, no aerodynamic considerations at all in the design of the LM. It only had to be designed to do one thing, and that is land on the moon, on a planet that had one-sixth the gravity of our planet. That's what it had to do.

SLADE: So it didn't have to be pretty.

FAGET: It didn't have to be pretty, it didn't have to be [aerodynamically] clean, and it's not pretty. [Laughter] It was nicknamed "the bug," which everybody objected to, so we stopped calling it "the bug," but it looks like a [huge] bug. And it turned out to be the right thing to do in many ways.

The other thing, which I mentioned before, was that our ability to track and to get velocity and position at these remote distances just improved tremendously in a matter of two or three years.

SLADE: Did the Surveyor Scout program help you out with that, or did that come—

FAGET: The Surveyor program helped to the extent that JPL [Jet Propulsion Laboratory, Pasadena, California] developed these huge tracking dishes, and along with that they developed a way to track with high accuracy. Not only could they get velocity with high accuracy, but position with high accuracy. This was actually a mathematical breakthrough, when they could filter the signals that came back and then get a high degree of precision.

SLADE: Yet [Neil A.] Armstrong and [Edwin E.] Aldrin [Jr.], when they made the first landing, landed down range a bit and were very difficult to locate on the surface. Is that another problem, or are we talking apples and oranges here?

FAGET: I don't know how much they missed their intended target. Is that what you're saying?

SLADE: Yes.

FAGET: No, I don't think that was particularly a problem. They went further than we might have, but the point is that we knew where they were. We knew where they were. That's what this tracking capability did.

SLADE: Where were you on that day?

FAGET: Where was I when?

SLADE: On the day they landed on the moon.

FAGET: I was in the Control Center.

SLADE: I know you must have been, and what was going through your mind?

FAGET: The same thing that was in everybody else's mind: "If they keep doing this, [hovering] they're going to run out of fuel." [Laughter] Really, you know, you couldn't really have a good hard feeling about just how far they were from actually landing. They kept going and going and going, you know, and finally they started descending. It seemed to take an extraordinarily long period of time, as an observer, which is all I was. It seemed like it lasted forever! [Laughter] Then they were down.

SLADE: Could you believe it?

FAGET: Could I believe it? Yes, I could believe it, but it was like, "Gee whiz." It was hard to—that was something.

SLADE: Well, I remember every step that we took. I kept thinking, "Now can they do the next step?" Was that the same feeling you had? "Okay, we're on the surface. Now can they get off?"

FAGET: I never worried too much about that. I thought they would be able to get out and move around. We'd done a lot of work on the suits at 1-G, and we knew that one-sixth G would be a lot better. We invented all sorts of ways to test those suits and the ability to walk. I don't know if you knew, we had this big circular place where we hung them on the side at an angle so that they essentially had one-sixth "G" contact with the surface, in that rotunda building there. I didn't worry too much. I don't know why. I didn't worry much about whether the suits would work or whether they'd get a hole in them or anything like that. What worried me was, would they ever get that thing down before they ran out of fuel. And then, of course, they had a rest and came back, watched them come back in. That was good. That was great.

SLADE: Then you knew you had a solid rocket to get them off the surface.

FAGET: Yes. That ascent stage, that was a pretty solid, compact reliable little thing. Of course, it had been flown. We'd flown it several times, not any landing, but exercises. We flew it once here in Earth orbit and one time in [lunar orbit]—so that came through all right.

SLADE: What was the biggest one challenge to Apollo?

FAGET: The biggest challenge to Apollo, I really think it was propulsion. You know, when we're in Earth orbit, when astronauts are in Earth orbit, they can come down so easy because all they've got to do is slow down a little bit, and they're going to come back into the atmosphere, and once a vehicle has been through an entry aerodynamically and you know it's controllable and all that, you don't worry about it burning up or anything like that. But when you're on the moon, you're in a gravity sink. Your propulsion system has got to work. It's really got to work. You can't wish your way out of that sink. [Laughter] You know, being in lunar orbit's one thing. You've got to come up with something like 2 or 3,000 feet a second to get out. On the surface, you've got to come up with a lot more than that to get out, and, of course, you've got to get up and make the precision of the rendezvous.

What you would call the mission analysis guys had to do a lot to make sure that they could abort anytime during the descent and still rendezvous and things like that. We carried a lot of propellant aboard for contingencies, and as we developed the flights and began to understand better, we gave up a lot of that contingency capability because we realized it wasn't necessary.

When we first started thinking about the lunar program, the question is, how much propellant did you have to have to correct for navigation errors [on the way out and during the return], how much spare propellant? If you make an error, the only way you can correct the error is to change the velocity, and the bigger the error, of course, the bigger the change in velocity. We were carrying something like 500 feet a second of propellant, just reserve propellant for errors in the first analysis of the lunar mission. By the time we actually got to flying, we were down to maybe like 100 feet a second. I think on some of the last flights we used maybe two or three feet a second on the way back from the moon. [Laughter] We actually had to use to correct errors.

What you find out is that is you can really track good and you can detect error when you're at the moon. Say you've got a tenth-of-a-foot-a-second error at the moon. If you don't correct that, by the time you get maybe a half an hour from hitting the atmosphere on Earth, that tenth of a foot a second could be twenty feet a second in correction that you'd need. So as our tracking capability improved, we could detect errors early, correct them early, correct them with assurance, you see. It's not that we were just burning propellant because we think there's something wrong; we know what to do, we know how much to correct. You really don't have to carry all that contingency.

SLADE: There were two episodes in Apollo which were calamities, one of them not so much as the other. The first one, the Apollo fire on the pad, what happened there? What was the pressure inside NASA that created the need to move into the program with a Block I spacecraft that you knew was not going to be the flight model, the full flight model? What caused that particular circumstance to develop?

FAGET: Well, we had Block I and Block II. Block I was in manufacturing long before Block II was, obviously because it was I instead of II, and it was getting close to completion, and it just made sense to go ahead and fly it instead of wait for Block II, because you had to make progress. There were a lot of things wrong with Block I, but the main thing that was wrong with Block I was not something that was anticipated in Block II, namely that there was too much flammable material aboard [and] that we didn't properly recognize how fast a fire would propagate and that there was not a way to get out. In other words, this hatch couldn't be done from the inside. Once the pressure started building up, it was glued in there.

SLADE: In a pure oxygen atmosphere.

FAGET: Yes. Hindsight is wonderful. We had the same atmosphere in Mercury and Gemini as we had in Apollo. They never had any fires. But, you see, after I started thinking about it, kicking myself for being so stupid, I realized that the difference between Mercury and Apollo was that one Apollo experience was probably equivalent to maybe twenty or thirty Mercury's, simply because there's so much more volume in Apollo and there's so much more stuff in Apollo, so that it's going to burn just as badly. It only takes a teeny bit of stuff, with some teeny bit of flammable material to ruin the whole thing, but there's so much less material in Mercury and so much less in Gemini, actually, than Apollo, that the odds of it happening in Apollo—you'd say, well, sooner or later it would have happened in one of the Apollo flights. It just happened to happen on this one.

As you probably know, I was on the review board after the fire. We never did find out what caused it, what specifically caused it, but the real reason it happened is that we had too much flammable material in there and we had a completely pure oxygen atmosphere. Now, one of the things that resulted from that is, we worked on both. We had a very extensive program where we actually tested the flammability of everything that went in there, and we coated stuff with nonflammable stuff and all that.

Did you know we came to an impasse, though? We found out that we could not completely be assured that we would not have a fire, in spite of all the changes we made to the material, and that's simply because we had an atmosphere which was about a half a pound of pressure greater than sea level of just pure oxygen in there. You say, well, why did we have the oxygen atmosphere in there? Well, it's a complicated story, but it's one that we're pretty much trapped in. It all gets down to the fact that we wanted to be able to go in and out of this vehicle in a spacesuit at any time without any pre-breathing, so we could not afford to have any nitrogen in the air if we were going to get the man down to possibly 3 psi, which is the lowest pressure that you might end up with when you go out in a suit. It doesn't take very much nitrogen in the atmosphere to give you the bends, if that's what happens. So we start off with the oxygen.

Well, I got to thinking about this, and I said, well, you know, you're not going to go out in a suit for a couple of days after we launch. So we went to what we call the sixty-forty atmosphere, which would solve the problem. Just putting that much dilution into the atmosphere, forty percent nitrogen, greatly reduced the flammability of a lot of things that we just couldn't make inflammable in tests.

SLADE: On the political side, clear up one—

FAGET: I didn't answer your question. You wanted to know about Block I and Block II.

SLADE: Yes. I'm sorry.

FAGET: I think Block II probably would have been just about as flammable as Block I. Now, there were other things that were not good in that spacecraft when you looked at it. The wiring was not too well done. It was not neatly done. There were too many fixes and so forth in the wiring, you know, which you might recall, where they just found there was something wrong with service, they'd just kind of tape over it or jump over it, put jumpers on there and things like that, just a lot of circuits that were added later on that weren't anticipated, which made for junky wire bundles. Obviously neatness is an important thing when you think about fire hazards. The spacecraft itself was not too neat in Block I as a concept, and all this was cleaned up in Block II quite a bit.

SLADE: I just wanted to come off of that, saying—and you can clear it up one way or the other—do you feel, on hindsight, that the agency was pushing too fast in getting ready to fly the Block I spacecraft?

FAGET: No, no. I didn't think so, no. If they'd said, "Relax, take another three or four months," we'd still have probably flown the same spacecraft, still would probably have run the same tests, still probably had the same goddamned fire. If we had waited until Block II, it might have been a little cleaner, but I'm not sure. There was an awful lot of stuff in there. They were using Velcro all over the place and they were patching up. Papers were here and papers there. It was just a relaxed attitude towards fire, which was not called for.

Now, we had asked Rockwell to—we gave them the title "fire marshal," you know, which is kind of like the guy who comes in the theater and looks around and says, "No, you can't have people in here. You've got this, that, and the other you've got to do before I'll allow this auditorium to be occupied by a big crowd." They had not done that yet. I'm sure they were going to do it, and, probably, given enough time, they probably would have done it, but I don't think it was high on their priority list.

SLADE: And then came Apollo 13, which some see as a triumph in many ways.

FAGET: Yes. Apollo 13 was kind of a funny situation. A lot of things set that thing up. I can't remember the exact details, but there was some problem with that heater before. They apparently went ahead and tried to use the heater, and it was not in a fluid, and I think in some of the tests they had done on the ground, that they had burned up some of the insulation in the wiring. Yes, that contributed. That was a contributor to it. But once we knew what it was, of course, we fixed it. It was not a difficult thing to fix.

SLADE: And the fact that, against all odds, the spacecraft stood up and the astronauts were retrieved, it seems to me, was one of the triumphs of the program.

FAGET: Oh, yes, that was a triumph. That really was. The fact that we had the LM there and that they could survive in a LM, that's about all you could say about it, but anyway, they could survive in a LM until they got back, was very good.

SLADE: It spoke to the equipment. Dr. Faget, your good friend Chris [Christopher C.] Kraft [Jr.] says that we probably flew Apollo enough times. Do you feel that it ended too soon, or do you agree with him? We only went to Apollo 17. The program was cut short. How do you feel about that?

FAGET: Should we have flown more often? At the time I felt like we should have flown more often, but now that I look back on it, I don't think it made that much difference, you know? You get wrapped up in programs. You want to keep going. No, I think that the time had come to do something else. The program that came up, of course, the Shuttle Program came. Let's talk about that tomorrow.

SLADE: Okay. Let's do that. Let's declare a moratorium and pick it up tomorrow, and we'll pick it up there, with the Shuttle. Of course, there were Skylab and the Apollo-Soyuz venture in between.

FAGET: Yes.

SLADE: We[re] those fillers, or were those useful experiences, in your mind?

FAGET: I think the Skylab was very useful, you know, a good thing to do. Apollo-Soyuz, yes, that was a good, useful program, too, from the standpoint of being able to make first contact with the Russians. Being as we're in there with them now up to our ears, we've at least got that behind us. I'm not going to talk about the Space Station Program. [Laughter]

SLADE: Why is that?

FAGET: Not unless you make me. That has been a mess. That has been a terrible mess.

SLADE: Well, we'll let you think about it overnight, and if there's a philosophical statement you'd like to make about that for the record, why don't you think if you want to do that.

FAGET: All right.

SLADE: Why don't we just break it off here. We've been at it for almost three hours. That's enough.

FAGET: That's right.

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SLADE: So it's now 10:15 on the morning of June 19, 1997, and we're resuming our interview [for the Johnson Space Center Oral History Project] with Dr. Max Faget at the Johnson Space Center in Houston. The interviewer is Jim Slade.

Dr. Faget, before we wound up our session yesterday on the 18th, you said something I thought was very significant, to me, that nobody ever talks about Mercury or remembers it much, but it was really pivotal. Why did you tell me that?

FAGET: Well, it had to do with timing. To be perfectly frank with you, when I was working on Project Mercury, and I think a lot of my colleagues never realized that the Russians would put a man into orbit before we did, and I don't know why we were so naive, but we just [moved the program along], so it came as sort of a surprise. I think probably higher management was probably aware of the fact that the Russians were making progress. I can't believe we didn't know what they were doing, but it never trickled down to the level of the troops in the trenches, that's for sure.

Nevertheless, we were able to get our first flight off with Shepard just a matter of weeks after Yuri Gagarin went into orbit, and I really think that timing made it possible for the President to jump on the fact that we were in a race with the Russians and that he wanted to win. He was not a loser; he was absolutely a competitor, there's just no doubt about it. But on the other hand, if we had chosen to go to some more elaborate approaches to manned space flight, I suspect we'd have been very easily a year or two years late, in which case I think we'd have been out of the race right at the beginning and we would just never have come out of the blocks, as a matter of fact. We would have not got into the race. So in many ways, I think Mercury pretty much jump-started the whole Apollo race.

SLADE: And you said that Mercury was an extremely simple spacecraft.

FAGET: Yes, it was. It would have never been done in the time it was done if it had not been simple, and I think it's worthwhile, perhaps, to review some of the timing. We, in NACA, along about the early part of the summer, began to anticipate that we would get the Mercury—well, the spacecraft program. At that time it wasn't called Mercury. A man named Chuck [Charles W.] Matthews, who you probably know, was in the Flight Research Division, he came up to me about that time, it was in June—I think it was June—of '58 and said, "You know, I'd like to be part of the program. I'd like to get in on this thing." I was going to Washington [DC], as I told you, as part of the transition team, you might call it.

SLADE: And this was from Langley at the time?

FAGET: Yes. So I said, "Chuck, you know, what you could do is get ready for buying the thing. Write a specification."

So he did. He started preparing a specification for the spacecraft in the event that we would put it out on bid, and he worked during the summer with just two or three of the fellows that had been working on it.

Then when, in October, Bob Gilruth got put in charge of the thing, we created the Space Task Group, we were [already] a going organization. It was not very long before we got the thing out [for bid]. As a matter of fact, we got it out in a month or so, and the responses to the RFP were back in time for us to work through the Christmas holidays, evaluating who should be the winner. We picked a winner in January, signed a contract, a preliminary contract, and negotiated the final clauses of the contract with McDonnell, and they were 100 percent on board by, I'd say, the middle of February. The contract was signed, sealed, and delivered. Now, mind you, to do something like that these days we'd have to study it for years, go through a bunch of hokey-pokey about making sure everybody was on an even playing field and all that stuff. And we didn't do that. We just went ahead and did the program.

At the same time that that was happening, in December—again, December of '58—I visited BMD [Ballistic Missile Defense] to talk about possibly getting some Atlases, and they said, "Well, we do them, Atlas A, B, C, and D. I think we can have two Atlas Cs available in the August period." He was talking about August 1959.

I said, "We'll take them."

I went back, you know, sort of like the guy that was on a hunting expedition and went out to get the bear. Did you ever hear this story?

SLADE: No. Go ahead.

FAGET: Well, this guy, he was with a buddy, and they went hunting for bear, put up a nice little cabin out in the woods, and his buddy asked him, "Where's your gun?"

He said, "Oh, I don't use a gun. I don't need a gun."

So the next morning this guy gets up at the break of day. The guy says, "Where are you going?"

"Well, I'm going hunting. You fix breakfast while I go hunting."

So he went out, you know. About half an hour later, here's this thrashing and crashing through the woods. He looks up and here comes this guy running towards the cabin with a bear behind him. He says, "Open the door. Open the door."

The man opens the door. The guy gets up to the door, and he kind of dodges to one side, the bear comes in, and he says, "You skin that one while I get another one." [Laughter] Well, that was kind of the approach we took. I'd get the Atlases if they'd take care of everything else.

But really, that put us on the spot, and we did build the Big Joe capsule. We built a boilerplate. I told you the story about that. We did not launch it in August. We launched it in the first part of September, though, from a standing start. Actually, we didn't have the final external lines of the vehicle until we got McDonnell…under contract, because these contractors had proposed slightly different mold lines for their vehicle. So we had to change the mold lines as soon as we got McDonnell under contract, which was in February. And we launched it, flew it successfully, as I told you, in a matter of six months.

SLADE: Amazing.

FAGET: And, of course, it followed on from there.

SLADE: When did you have your first fully operational spacecraft in the house?

FAGET: I think John Glenn's spacecraft was shipped to the Cape something like about six to eight months before we actually flew it, which would have been in 1961. Mind you, this was like two and a half years after we had McDonnell…under contract, and they hadn't even cut the first piece of metal.

SLADE: Who built the Shepard and Grissom spacecraft?

FAGET: McDonnell…did the whole thing. We ordered something like twenty spacecraft, and they were turning them out practically once a month there toward the end.

SLADE: You told me about getting the Atlases. How about the rockets that launched the suborbital flights? Were those in the inventory already?

FAGET: The Redstones were further along than the Atlases, and we went down and negotiated with the Army, with Von Braun and company, for the Redstones. There was a little bit of a problem there. Von Braun wanted the capsule to come to his plant before going to the Cape. We said, "Well, why do you want to do this?"

"We have to have an integration test, and we want to do it here."

Well, we'd gone way out of our way to make [the] interface between the capsule and the vehicle very simple. That was one of the reasons we could move so fast. We had an extremely simple interface between the capsule and the vehicle. So we just simply didn't understand that, and we had a big argument about it. He really wanted that spacecraft there. So I don't know, they seemed [to want to be the dominant player] of the program or something. But we talked them out of that.

SLADE: Well, you're a stubborn guy and so is he. How did you two get along?

FAGET: We had a lot of pretty stubborn people, but I think the main way that we got along was simply that we identified [the interface]. We got together with the people that were building the Atlas and the people that were building Redstone and identified a very simple interface. We knew that we had to have an abort system, and that was probably the most complicated part of the interface, so we invented the simplest imaginable abort system, which was actually two hot wires going from the launch vehicle to the spacecraft. If those two wires lost voltage, we'd go. It was just that simple. And the reason we [used]…hot wires is because automatically that represented an electrical failure. If the launch vehicle had an electrical failure, we didn't have to sense that. Those wires would lose voltage, and we'd go.

And then we picked out a number, about three or four other things like too fast a rate of pitch or yaw, loss of pressure, feed pressure, and things like that which would also indicate a coming disaster. And of course, the escape rocket would leave at 20 Gs when it got triggered, so it would go off. In addition to that, we could radio a signal to abort from the blockhouse, as well as the people in the vehicle had what we called a chicken switch, which was really the—the handle they used to steer with [after]…launch, if they flipped it over to the right, that would trigger an escape.

SLADE: Boy, they'd keep a cool, steady hand. [Laughter]

FAGET: Well, I think they kept their hands off the thing, to tell you the truth. [Laughter]

SLADE: Now, you said that the escape rocket which you invented was a Polaris?

FAGET: It originally was a Polaris. When we actually put an escape rocket on, we had to have a specially designed rocket. We used an existing rocket to demonstrate escape, but it was not quite up to performance, but it was an existing solid rocket. What we wanted was a lot of thrust and a very short burn time. We wanted all of the propellant in the rocket to be used up as quickly as possible so the thing would really accelerate. The distance between the spacecraft and the exploding launch vehicle was the main purpose of the escape rocket, of course, plus it had to provide enough altitude, if they were going to escape off the pad, for the parachute to operate. Those were the two criteria: high acceleration and several thousand feet of altitude.

SLADE: Were you happy for the chance to do the chimpanzee flights?

FAGET: Well, the chimpanzees—of course, we started off with Rhesus monkeys. We had, I think, two monkey flights and then two chimpanzees. They were externally dictated to us. We didn't have anything at all to say about that. As a matter of fact, we were under orders—I wouldn't say orders, but we were under a lot of pressure to make at least six chimpanzee orbital flights. That's what the National Academy of Science had recommended that we do, six of these flights with monkeys before we put a man in there. Of course, we couldn't understand why they wanted to do that, but it turned out that when Yuri Gagarin flew and he got back all right, it sort of negated the [pressure for] six flights. We did have the one flight to really prove out the environmental control system, which was fine.

We also flew what we called a "canned man," which was really much better than a live animal. A canned man was just a box, a pressurized box, that took the place of the couch in the capsule, and this pressurized box would turn oxygen into CO_2 and water and put out a certain amount of heat to challenge the environmental control system that was keeping the pilot cool and was providing him with fresh, breathable oxygen. So we could actually make measurements on that. I'm talking as an engineer, not as a medical person. The chimpanzee flights and the Rhesus flights were to make the medical people comfortable with the program.

SLADE: Did you get along with the medical people?

FAGET: There was always a certain amount of friction between the engineers and the medical people. There was a great deal more friction between the astronauts and the medical people. There were certain measurements and so forth that the doctors want[ed] to perform on the astronauts that they kind of resented. They felt like they were being made a guinea pig. However, I think they were justified, and the medical data was useful during the flight, I thought.

SLADE: They took a lot of teasing from the other people in the Society of Professional Test Pilots, didn't they?

FAGET: They sure did. [Laughter] But I don't think they would traded places with any of those professional test pilots. I think they were very happy to be where they were. There was a certain amount of jealousy as well as the teasing going on there.

SLADE: I remember one time I interviewed Neil Armstrong when he was still flying the X-15, and he had no intention of coming over to the Apollo Program.

FAGET: But a chance at the moon would change his mind in a hurry, I'll bet.

SLADE: Exactly.

Well, let's move on. We could talk about Mercury all day long, I think, and both of us have a good time, but let's move on to the Shuttle era. Many people who don't know the program probably don't realize that those weren't that far apart. When did you start taking an active interest in a Shuttle-type design?

FAGET: Actually, that was in the early part of the flight program of Apollo, during the second or third mission to the moon. The story is very simple. Everyone was convinced that we had leapfrogged from orbital flight to lunar flight and completely left out a Space Station. Space station seemed like an obvious thing to do, to have a laboratory in space where people could work and we could understand microgravity effects both on people as well as physical processes a lot better with a laboratory than we could in these tiny capsules. So there was a big effort towards the beginning and middle of the Apollo Program and increasing as we went along towards building a rather large laboratory for flight.

One of the interesting asides was there was a lot of concern about maybe we should have artificial G in this laboratory. Of course, we found out later that artificial G was not really necessary, so that got dropped later on, but not at that time. There was a big, big concern for artificial G.

But as we got deeper and deeper into the Space Station Program, it became obvious that we needed a better vehicle for servicing the launch vehicle. Gemini was too small, Apollo was too expensive, and it almost looked like an overkill. The Saturn launch vehicles were quite expensive, so even though you might make the capsule to carry more people, the launch vehicle was—

SLADE: They were also very labor-intensive, weren't they?

FAGET: Yes. So we started looking at a brand-new vehicle, and the first shot at it was we would design a new launch vehicle, perhaps using one F1 engine, as opposed to eight of the other engines that went on the Saturn 1s to simplify the cost, the operation, and put a larger capsule on it. We had versions of twelve men in a [Apollo] expanded design and twelve men in a Gemini expanded design. So both McDonnell and North American were competing to provide a capsule which would carry twelve men for servicing a Space Station.

George [E.] Mueller, really more than anybody else, pushed us into the reusable spacecraft. He visualized that we [NASA] really…want[ed] to do that. We wanted a reusable spacecraft which could fly often and could be used over and over again, and so we got into this program of a reusable Shuttle, and it was going to be a two-stage spacecraft with both stages having wings and landing gear and being able to land on an airport and be reused. That went through a series of evolutionary processes when they began to study the thing, and then we got a better and better idea of the implication of total reusability.

As you know, we never did build a completely reusable vehicle. The first thing to go was a reusable first stage. We wanted to make the second stage reusable because we knew we had to get the astronauts down. We could expend the first stage, but we couldn't very simply make the second stage reusable without having to resort to a separate capsule and all, which was going back too far. So we went through a number of steps, but we arrived at the final configuration you saw.

That was a very interesting activity. It started around the end of the 1960s and the beginning of 1970. I think the first step that I put on it was actually in 1969. We formed a small group of people at the Johnson Space Center with the idea of looking into the feasibility of a completely reusable two-stage vehicle. Now, it started off primarily as something that's a lot smaller than the present Shuttle, with the idea that it would carry perhaps half a dozen up to maybe eight, six to eight people up into orbit and perhaps 2 or 3,000 pounds of cargo at the most.

At that time, the NACA needed help with Congress, so they negotiated with the Air Force to use the thing, and the Air Force said, "Well, we'd be glad to use it, but you've got to make the cargo bay much larger and you've got to carry a lot more cargo than you're anticipating," which, again, made the feasibility of two stages completely reusable very, very difficult. The first stage got to be, with weights at landing, of 800,000 pounds. So you can imagine just—and even with those big stages, there didn't seem to be an awful lot of weight margin for growth, weight growth, and people were rather uncomfortable with the idea of going ahead with that.

So the next step was to go to an expendable first stage and stay with a reusable second stage. Now, from the very start we recognized we had to have high performance, and we were going to use hydrogen fuel, which, of course, gives a lot more specific impulse than the kerosene, but it's also bulkier. It wasn't very far along before we decided, well, there was so much volume tied up in the hydrogen tanks, we'd better put the hydrogen tanks on the outside. So on the second stage, which was the recoverable stage, we had one hydrogen tank on each side of the vehicle sitting above the wing. But, still, in my opinion, the design didn't close sufficiently to feel comfortable with it.

The problem, of course, we were continually thinking about having the first stage attached to the second stage and the tank, in turn, attached to the second stage. At this time I came in with, I think, a very good idea, which was, don't attach the second stage to the first stage. If you're going to attach all of the tanks to the second stage, you'd have this little second stage which might weigh a quarter of a million pounds, and then you'd have a million and a half pounds of tanks attached to it. Now they're going to be running an awful lot of loads through this [weight-sensitive stage], and it would make it hard to keep the weight down on the Shuttle's return stage. So I said, "Why don't we put the return stage on top of the tank, and then put the weight of the tank directly on the launch vehicle?" So we had a pretty good design at that point where we had an expendable launch stage using pressure-fed engines, which was a mistake. We should have used F1 engines or something like that for that expendable stage and then had the second stage tank on top of that with the orbiter sitting on the side on top of the tank, on the side as far as the launch vehicle's position was concerned.

Then John [F.] Yardley came up with the idea of using solid rockets alongside, which provided the opportunity to light both the second stage and the solid rockets at the same time. I was working very closely with the people from Boeing, and they pointed out, well, you could do that. You could also still keep the liquid stage behind the thing and light the engines at the same time. But the NASA officials had already shown the solid rocket configuration to the President, and he said, "Go ahead," and pretty much set things in motion.

SLADE: That was President [Richard M.] Nixon.

FAGET: Nixon. The mistake we made on the solid rockets, it was a major mistake. I always thought it was. I know it was a mistake, was that we decided that we'd build the solid rockets in Utah, and that limited the size of the solid rockets. It also meant that they had to be segmented. But the size limitation was probably more serious than the segmenting. The diameter of the solid rockets had to be less than twelve and a half feet in order for the existing rail transportation, which had to go through a number of tunnels and so forth and so on. We just simply couldn't make it any bigger around than that.

What was also a factor in the design of solid rockets was that you can't make them but so long. The length-to-diameter ratio is a limiting design factor, and consequently we limited the total amount of impulse, thrust times time. The total amount of propellant in the solid rockets was limited by that, which meant that the solid rockets would only be able to help during the first couple of minutes of flight, as opposed to being attached longer. We staged those solid rockets at only a little over 4,000 feet a second, which really meant that the Shuttle and its tank had a big job to do, and it really limited the performance and inhibited any growth in the payload capability, which the program has had to suffer with all this time.

They did another thing. When [the solid rockets] stage at 4,000 feet a second, [the orbiter] had to have an awful lot of propellant left for the insertion, which meant that you had to have enough thrust to carry the weight of that propellant, and that increased the size of the engines in the orbiter, which moved the center of mass of the orbiter farther back than we would have liked in order to make it tail-heavy. As a consequence of that, the center of mass of the orbiter was well behind the center of volume of the payload bay. Being as we didn't have a tail on the damned thing, we had very little capability to move the center of mass and maintain stable, manageable flight. A consequence to that means that a good part of the front end of the payload bay is virtually useless, has been useless all the time, which is kind of a too-bad thing.

But I'm just trying to illustrate some of the [arbitrary] decisions that were made as we moved along and that ended up providing a penalty to the program. I want to make it clear, I think that the Shuttle vehicle is a masterpiece of engineering. The fact that we've flown it that many times and only had one loss of vehicle—by and large, it's performed marvelously every time. But it's the only case that I know of where a major change, a major new kind of system has been created, put into operation, with no process of evolution to improve that vehicle. We not only built the Shuttle, [if] we had an opportunity to build a second [generation] Shuttle, we'd make it a lot safer, we'd make it a lot better performer, a lot more economical, so forth and so forth and so on. The unfortunate thing is you can't build a second one without building a first one, and we only had enough money for one.

The other thing that has been kind of bad is that the Shuttle has been so expensive to operate, there has never been any money set aside to improve it. It's unusual. All of our airplanes that go into operation, they get improved. I'm talking about military airplanes, but particularly they get improved as they go along. So there is not an evolution in the case of species, but there is an evolution within the particular vehicle. That didn't take place, didn't take place [in the Shuttle]. Virtually, from an engineering standpoint, there's hardly any difference between the Shuttle we're flying today and the first time we flew the Shuttle.

SLADE: It's a frozen design.

FAGET: Yes. So the design has really not been changed. There have been a few little niceties put in, primarily to make the astronauts happy. Nothing has been done to make the vehicle better from an engineering standpoint, other than some small improvements in electronics. The computers we started off with are really ancient, and there have been some improvements there, but they've been very minor. There's been no major change in what you might say the computation network. We're staying with the thing we started with, all these computers in parallel and so forth and so on. A more modern approach would subdivide the computation instead of trying to run everything through the—[primary system.]

SLADE: But do you have the latitude to make radical changes like that in this design?

FAGET: Of course we do. Of course we do. It just takes money. We don't have the money. We don't have the money. There's also this business that people are afraid to make big changes because the new thing might not work as good as the old thing and we might have a casualty.

One of the other big mistakes we made was never flying the thing unmanned. I wish you'd ask Chris [Kraft] about that, because he's been in Operations. That's been his business, and he'll tell you exactly what I said, that we should have flown it unmanned. We should have unmanned flights. The unmanned flights, if nothing else, would give the engineers the opportunity to experiment in improving the systems without risking human life, which was a big inhibitor on any change, you see. So we have a much better way to operate the thing, plus the fact, if we took the crew out of there, we could probably carry another 15 or 20,000 pounds of cargo, which would solve all the problems with the Space Station. Instead of all these numerous launches, we could probably cut the number of launches in half if we could carry things up in bigger bundles.

SLADE: Why didn't we do unmanned flights? You did it on everything else.

FAGET: It's the usual thing. The program is in the control of people who are hard to move from the status quo. We don't have any bold people in NASA anymore, absolutely none of that. Everything is done very conservatively. We'll never get back to the moon unless we change NASA. I'll make that in a statement. I'll say it again: we'll never get back to the moon, something as simple as that, unless we change the way we do things.

SLADE: Why?

FAGET: One, going to the moon is actually absolutely ridiculous for a commercial enterprise, and the government has moved to such a safety-conscious attitude, no risk-taking approach to life, that I just don't think we'll do it. We'll talk about it a lot. We might send unmanned vehicles to the moon. I hope we do. But to send a man to the moon and the planets is going to take an earthquake in management to do that, an earthquake in our culture to do that. The culture is moving absolutely very strongly in the wrong direction.

SLADE: I take it you don't believe that current management has that vision of the faster, cheaper, smaller.

FAGET: If they had the vision, it wouldn't make any difference; they couldn't sell it to anyone up the line.

SLADE: Which brings me to a question I wanted to ask a little while ago, the part that Presidents, the political administrations, have played all along. I know you had the great cheerleader in John F. Kennedy, but after that, how did it change?

FAGET: Well, for one thing, the immediate Presidents that followed Kennedy were willing to more or less ride on momentum. Certainly Nixon had a wonderful ride. He got his name on the moon and everything else. He didn't have anything to do with it, but he rode it. Well, he was the President of the United States. I think that was proper. I'm not criticizing him for that. I'm just saying he had a pretty good ride of it. He did approve of starting the Shuttle Program. I think he did. Maybe it was some other President. I don't know.

SLADE: No, he did.

FAGET: He did. So that was good, you know. Then the Democratic Presidents that followed were not interested in space. They were more interested in culture. They more or less ran on that. Of course, we didn't get the Space Station started until [Ronald] Reagan. We had to get another Republican President in to start the Space Station.

SLADE: I notice you haven't mentioned Lyndon Johnson, whose name was on this Space Center for a long time and who was instrumental in moving the Space Center here to Houston. What about him?

FAGET: I guess I'm a Republican. I'd rather not tell you what I think about him. [Laughter] I'm dodging. He just rested on the oars—a Navy expression. [He did get a lot of credit for moving the center here. But Albert Thomas , as head of appropriations in the house should get that credit. Johnson was Vice President at the time and therefore an impotent official.]

SLADE: So actually you're saying that the impetus to get us on the moon started with Kennedy and carried like a tidal wave on through to July of 1969.

FAGET: Swept through, and then the tidal wave resided, and the seas are very calm. It's going to take another earthquake.

SLADE: What do you do with an agency that has such a magnificent track record and has so much capability and goes casting about for a job? Who ought to be searching around for the way this agency should go?

FAGET: I really don't know. I could tell you it's not my problem, thank God, but it is in a way. My children are deeply involved, too, deeply involved in space. I just feel bad about what I see. We will probably end up doing the Space Station. It's going to be a tough, tough, tough battle all the way, but I think it's got enough momentum to go off.

SLADE: Let's get to that in a minute, and let's finish—

FAGET: But to go beyond that, it just baffles me. You know, we talk about NASA, talk about a new initiative, going to the moon and then perhaps to Mars and things like that, which is good. The opportunity to do it, you know, the commitment to do something like that is going to be very hard to come by. It's going to be hard to come by. Let's go back. If we try to go to the moon with the approach that we've [now] taken where you've got to be ultra-safe, it's going to be very difficult. Very difficult.

I'd like to go back to the Shuttle.

SLADE: Yes. I wanted to do that, too, because I want to get to those other things as we conclude.

FAGET: Let's go ahead with that.

SLADE: Let's do go back to Shuttle for a few minutes.

FAGET: I'll tell you, we did end up with the Shuttle with the tank underneath and the solid rockets on the side. Bob Gilruth was no longer the Center director, but he had an office in the Center, and I would talk to him quite often, and again, he asked me, "What are you going to do about aborts on the Shuttle?" At the time I said the Shuttle was not going to be able to abort. He said, "Well, that's not good. You ought to think about it some more."

And I did, and I came to the conclusion that we could actually improve the performance by moving the engines out of the return vehicle and putting them on the tank. Of course, that would mean throwing away valuable engines. So the next step was to think about how you could move the engines back and bring them home, which turned out to what we call the swing engine concept. The nice thing about the swing engine concept that it was very appealing from an abort standpoint is that you could abort off the tank anytime you wanted, absolutely anytime you wanted, and you could carry in the Shuttle a solid rocket which would propel the Shuttle.

The idea was to move the engines from the rear of the tank. At one time I was going to move them into the payload bay, but then the engines got too large when we ended up with solid rockets. That inhibited that approach. So the next thing was to move them back to where they are now, but after you got into orbit, to then move them back. In the meanwhile you could replace them with the solid rocket in the back of the Shuttle, and this solid rocket could be dropped when you got into the upper parts of the atmosphere where an immediate abort wouldn't be normally required but there would be no air loads on the vehicle, and if the engines blew up, they were not in harm's way, they'd be back on the back of the tank.

SLADE: At what time was this discussion taking place?

FAGET: This was taking place about six or eight months before we put the thing out on bid. It turned out this improved the performance. I won't go into the reasoning behind this, but it really did improve the performance. It also allowed the vehicle to land with heavy cargo in the vehicle, because if you aborted, you wouldn't have the weight of the engine in the vehicle, so you could land the vehicle.

SLADE: Let's stop and draw a picture here for a second. You're talking about putting the engines that we know on the Shuttle today on the back of the tank and having an escape solid rocket in the tail of the orbiter.

FAGET: In the tail of the orbiter, yes.

SLADE: That was your concept. And that improved performance?

FAGET: Yes.

SLADE: Were you still considering the two solids on the side of the tank?

FAGET: Yes, we were pretty much stuck with that.

SLADE: So, two solids.

FAGET: It would have been better with the more energetic solids.

SLADE: So you had everything along the center line of the tank, all of your main thrust through the center line of the tank?

FAGET: Right. Which was—that's simple.

SLADE: All right. I'm with you now.

FAGET: Then after you got into orbit, there would be something that looked like grasshopper legs in the back of the Shuttle which would be attached to the engines, would separate from the tank, much the same way the orbiter separates from the tank. You'd still have the big ducts that would carry propellant in the engine. You'd have a separation system there. You would not have to have a hole in the bottom of the Shuttle for them to come in, but the engines themselves could come off, and they'd be tucked-up into the back of the orbiter.

SLADE: You made an Atlas missile out of the tank, didn't you? [Laughter]

FAGET: [Laughter] Well, anyway, the thing did have marginally better performance, near as I could tell. [It eliminated the large thrust loads through the orbiter to the heavy tank.]. We never went that far with it. I got some people at Rockwell quite interested in it, and the people at Grumman were very much interested in it. They thought it would be a very good, workable idea. So I tried to get that change put through, and everybody said, "Well, we've had everybody studying the present thing. If we change it now, we'd have to let them study longer." I don't know. I guess so. I don't know. But you know how management gets. They see the goal in mind and they're not going to except any change. I could understand that philosophy, but it did leave us with a system that you can't abort.

If there's a necessity to abort from the tank, you have to wait something like six seconds to slow the velocity of the fluids that are coming down this big pipe into the orbiter before you can shut the engines down. In other words, you know what a water hammer is. You just shut the valve, the big ducts blow up, and you've really got yourself a problem, so you have to slowly shut the engines down. After the engines get shut down, then you can abort. Plus the fact that the engines themselves might be the criminal, and if they blow up, you're blowing the rear end off the orbiter. Here, if you've got them on the tank, if they blow up, they blow up the rear end of the tank.

SLADE: And you've got a glider.

FAGET: Yes, you've got a glider, which is all right, and it's got a solid rocket in it so it can get away from that mess and so forth. It was a good idea. It was just a little late. I look at it philosophically now. I was a little bit upset about it at the time. I actually convinced people that it was a good idea, but it was after we had Rockwell under contract, and they didn't want to change it at that time.

SLADE: Most of the abort modes that are described for the uphill climb do include aborting with the tanks still attached, don't they? Even if you lost an engine and you tried to do a transatlantic abort.

FAGET: Oh, yes. You have to stay with the tank. I mean, yes. Well, this wouldn't preclude that type of abort mode, where you just lost an engine, safely lost an engine, shut it down, but if you lose an engine in the orbiter because it simply blows up and comes apart like they've done in the test stand, it's very interesting. We've had at least three catastrophic failures with an engine in the test stand, which, if that engine had been running on the orbiter, we would not have been able to sense and shut the engine down in time. We've had three of those on the test stand. We've been very fortunate. It could have occurred on the orbiter now. People deny that. They'll say, "Well, we had it on the test stand. We found out what was wrong and we fixed it." As a matter of fact, we have not had any test stand failures since we started flying, but we had some after we thought we were ready to put the engine on orbit. [Laughter] We got rid of all of the what you might call the early childhood diseases early in the game, and then no more showed up.

SLADE: We did have one catastrophic failure. How did that happen?

FAGET: That did not include the engines and the orbiter.

SLADE: No, I saw the engines still running.

FAGET: The engines were still running.

SLADE: How did that happen?

FAGET: Well, that happened because we had segmented rockets. NASA did not recognize the fact that the very cold weather would make the rockets leak, more likely make the rockets leak, and they should have never made that launch. They had every warning sign not to make that launch, and the time constant between the people down in the trenches and the people that were running the Shuttle was too long to stop the launch. It was unfortunate. The problem was picked up—probably before the first flight there was some concern about joints leaking. The people that were in charge of that program thought they were on top of it, and we went ahead. They did have plans to improve the joint, which would have maybe taken place a year after the actual accident. It's hard to say when that would have been implemented, but they recognized that that joint ought to be improved.

SLADE: Were they pushing too hard to meet a schedule?

FAGET: I doubt that. I doubt that. It's a funny thing about launch holds and so forth. You get to the point in a launch where it's better to go ahead knowing there's a slight risk that's extremely slight—I'm talking about extremely slight risk—than to stop and shut down, and then when you shut down, the fact that you shut down and all that, you may be creating new problems that will go unrecognized.

SLADE: Damage to the system?

FAGET: Yes, every time you cycle a system, unless you go all the way back to the VAB [Vehicle Assembly Building] and essentially go through a brand-new cycle of things, you don't have a thorough verification of everything like you do when you leave the VAB area and take it out to the pad. So unless you're willing to bring everything down on the pad, disassemble the whole launch vehicle, and put the orbiter back in its facility and all that, you may have created some problems.

So once you get far enough along, if the problem appears to be extremely slight, the thing to do is to go ahead. It's not schedule pressure as much as what makes good sense. Otherwise, you understand, you get to the point where you've got to go back. There's so many, many things that are on board that are involved that can cause a problem. If you've got one little teeny problem here, you have to do a half-assed recycling by just holding for a couple of days while you fix that little thing. Meanwhile, you've degraded multiple other systems ever so slightly, but you've got to look at the whole problem, and that's what the launch managers do, and that's why when they get so far along they really want to go, and it's an absolutely reasonable and proper decision.

SLADE: And those conditions pertained the night that *Challenger*—

FAGET: Yes, this came late, you see. This came late. That cold weather was unexpected, and the result of that was—the main concern about the cold weather was ice would fall off and damage the tiles. An inspection showed that was not going to be a problem, so they went ahead.

SLADE: What's your opinion of the changes that have been made to the Shuttle as a direct result of the *Challenger* accident? Were they in line with the need, or were they overdone?

FAGET: They were overdone. There were a lot of changes that were made that—some of them marginally improved the thing, but they were shut down way too long. I'll give you an example. In the case of fire of Apollo, compare that with the Shuttle.

SLADE: You were down eighteen months after the Apollo fire.

FAGET: The Apollo fire and the accident happened, both, right at the beginning of the year. If you look at the time, what happened after the Apollo fire, two and half years later after the Apollo fire, we had a man on the moon, okay. Two and half years after the Shuttle accident, we made the next flight. Before the Shuttle accident, we'd flown the Shuttle some twenty times. It was a good vehicle. Everything was working. The thing that wasn't working good was the solid rocket motor.

Before the Apollo fire, we hadn't flown it at all. We'd never really flown anything at all. [Laughter] We'd flown some high-velocity tests but never the total system had ever been flown. We were able to get to the moon when we were on the fast track. When we were on the slow track, it took us the same amount of time just to get back into orbit.

SLADE: You like to run on the fast track, don't you?

FAGET: I think that's the only way to go. [Laughter]

SLADE: What was most interesting to you about going to the moon? Was it the science or the engineering?

FAGET: Both. I got wrapped up in the science. I'm not a scientist, but I really got very, very involved in that. It really sparked the imagination. The engineering problems that were involved had this scientific aspect to them. In other words, it was conjectural science data. Imaginary problems were not imaginary problems. We didn't know what kind of moon we were going to land on. We didn't know what the radiation environment would be like near the moon. Just a whole host of things like that that we didn't really know, and we had to move ahead anyway.

SLADE: Has there ever, in the history of humankind, been such an intense burst of science and technology as during that one period?

FAGET: I think, if you look at what happened at the beginning of World War II in this country, a tremendous burst of activity, tremendous. I told you I was on the submarine. My submarine was built in Manitowoc, Wisconsin, up on the Great Lakes. It went down the Mississippi River in a floating dry dock. The people in Manitowoc had been building ore-carrying ships and tugs, you know, whatever you used on the lakes, and they were a big builder. When it came to the war effort, we weren't going to fight a war on the lake, so these guys were looking for a job. They approached the Bureau of Ships with the idea of building destroyers. [They could]…build a destroyer that could go out [the lake through the locks and into the Chicago River and down the Mississippi and into the gulf]….

[But] the Navy wanted submarines, and they told them, "Well, we're building these things in Connecticut. You work with EB, Electric Boat, in Connecticut and get the plans and build one." Well, they had never built a submarine before, didn't know the first thing about it, and they had an engineering staff of maybe five or six people, but they sent the engineers over to EB and came back with plans and got a contract to build a submarine. I think they were able to christen the first submarine something about a year after they committed to this thing. Damned good submarines. I rode on one, and they were beautifully built.

I mean, that's when you've got a real burr up your rear end, boy, you're going to move. So we moved in World War II. No doubt about it. And it was done without computers and anything else, you know. You just made it. We've got great technology, but the culture in the country has become a lot more conservative and cautious. I don't know. I think if we had a real crisis, we could respond a lot faster than you think.

SLADE: Well, here we are at this stage of development, and I agree with you, I think we've had an evolutionary turn in human development in the past, say, twenty-five to thirty years because of the way we look at the world today. It's different than when my father was a boy and your father was a boy. We see it differently, we think about it differently, we talk about it differently, and we've seen other worlds. So we've had a change. Now are we just sort of coasting along trying to assimilate all of this? We're beginning to make deals with the people we used to compete with in order to continue in any fashion at all. Is that because it's too expensive, or is that a logical thing to do?

FAGET: Well, I can only think it's logical. It's logical within the culture in which we live, but it's not the way we used to do things. You're certainly right. I think we're in a very good age in this country here. We talk about—well, industrially, we don't have near the number of people working in factories or on the farm or anything else. Really, most of the people, somehow or other, are in the superstructure here, as opposed to down in the bowels of the ship really turning out hard copies, you see. But nevertheless, it works, and we go ahead. Compared to the rest of the world, we're doing grand. We're doing grand. So you can't argue with what we're doing.

I think the breakthroughs we've made in electronics are going to take a long time to assimilate. The mechanical engineering has not kept up with the electronic engineering, electrical engineering, and the science, high-level science. So we live with that. Well, I don't know what to say. I think we could do better, but I don't think we will.

SLADE: Are we going about putting together, in this time when things are moving along so well you tend to sort of drift along and enjoy it, are we going along in the right way in producing a Space Station? Do we need a Space Station at this point?

FAGET: We could do without a Space Station, you know. Space station doesn't serve any vital interests, needed vital interests. However, we've got to expand what we do. We've got to look into the new ways, new frontiers, because that's the basis on which growth comes. You can't find out anything you don't know unless you risk a little bit of time looking into new things. So I don't know what the Space Station might produce. I don't know what side effects it might produce. But compared to the total national output, the total national economy, it's a small drop in a big bathtub. So we should do it. But that's not the only thing we should do in the way of just fundamental, blind experimenting, blind activity, that we're led just by our curiosity.

Man's curiosity is the big driver behind all the things that happen, behind all progress. The trouble is, of course, that most leaders in any country don't have a great deal of curiosity. They have a great need to maintain the status quo. They're sitting where they want to be, and so why rock the boat? But there's always going to be people that have curiosity, and they have to be supported. The same way we've got to support the arts, we've got to support the curious.

SLADE: You're right there with me. You're getting ahead of me, as a matter of fact. Let's just step back for a moment and then we'll come to a conclusion. The Russian, the European, the Japanese, the Canadian participation in a program which once was unilaterally this nation, is that the only way this program can survive? Is it a good thing to do? Should we help to carry the Russians if they can't financially keep up with the demand of the program?

FAGET: I think we're committed to the program. There's just no doubt about it. The question is, is it the right thing to do, that is about three years gone by when that was an issue. As you probably know, we're collaborating with the Russians not just because it's good for space, but for numerous other reasons which make sense. So here we are. We're committed; they're committed. Let's do the best we can. And there's no doubt about it, we've got a cripple as a partner, so we're going to have to help the cripple along. We can't expect them to carry the same kind of load that our economy can support or the European or the Japanese economy, and we're the big boy. We've got to pick up the load for the Russians. We can't expect the Japanese to do it. Lord knows they probably still hate the Russians. And we sure can't expect the Europeans to do it. So it's up to the man with the big shoulders, which is the good old U.S. of A., to keep the thing going.

In the long run, though, competition will lead to a lot more progress than collaboration. We can't afford to eliminate competition just because this might be an easy way out. We really ought to try and do something. If I look at the space program right now—and I mentioned this yesterday—I think the big thing that has to be done is to improve our launch capability, put it much more on a business-like basis than what we're doing. It's a fragmented activity. You've got a lot of companies involved, virtually no competition. The only company that I know of right now that has got any chance at all of making a major improvement in launch vehicle technology in this country is Kistler [Aerospace, Washington], and unfortunately, I don't think—I'm concerned that it might be too big a thing for them to swallow. But at least they're making a heroic effort at building a commercial launch vehicle that will be fully reusable. They've got a lot of major problems, and God bless them, I hope they do it, but I really think that NASA is wasting the opportunity to support the right kind of launch capability.

SLADE: You don't believe the X-33, X-34 concept is going to go?

FAGET: I think that the money they're spending on X-33, X-34, and X-38 is not money well spent. I don't think that will lead to—well, if any, just a small part of it will lead to real progress. We really need, as I told you earlier, to get behind a really sensible first stage that's completely reusable and piggyback off of the that a event [till] you get the capability to have a two-stage reusable vehicle. But the thing that we can do now, the thing that present technology can support, the thing that will give it a good running start, would be go ahead and produce a good reusable first stage.

SLADE: That you could reuse over and over again and get it back.

FAGET: Over and over again with virtually no changes, only the same kind of maintenance you might do on an airplane.

SLADE: And how about humans as anything but passengers? Do you believe that the spacecraft should be flown manned or unmanned, either way?

FAGET: I think the Shuttle ought to be flown unmanned, simply because that would return it to a semi-experimental vehicle, the unmanned version, plus the fact that it would solve a lot of our transportation needs. If you go in there and take out all the systems that are man-supporting, you save an awful lot of weight, and then if you take out some of the what you might call reserve propellant, reserve this, reserve that, associated with manned flight, you'd also make gains. Like I say, you can get 15 to 20,000 pounds out of such a vehicle. [When it comes to passengers, I think that the vehicle should be under the control of a trained crew.]

SLADE: And still have a recovery, a return vehicle.

FAGET: And it would be cheaper to turn that vehicle around. There'd be a lot less to do to it, you see. It would be a simpler vehicle to turn around.

SLADE: What happened? Those figures that were first proposed for the Shuttle, a short turnaround, forty to sixty flights per year, relatively low cost, where did those numbers come from and how were they so far off the mark?

FAGET: A very interesting thing happened to the engineering design on the Shuttle. The engineers that were designing the Shuttle—I'm not talking about just the engineers here, but the whole establishment—said the way to make the thing inexpensive to turn around is to put enough redundancy in it so that you can launch with systems that aren't working. So, instead of putting three levels of redundancy, which is normally what had been used—as a matter of fact, we went to the moon in many cases with only two levels, a main system and a back-up. In the Shuttle we put in four levels so that while you're counting the thing down, if something fails, why, you just launch anyway, because you've got three good systems, which is all anybody would ask for.

Well, it turns out that it takes an awful lot longer to make four systems work than three systems work, a lot longer to check it out, to make sure the [redundancy is all in order and the failure detection systems are all working]. So although we've got something that would be launched with three good working systems, we've got a probability of the fourth system going down and stopping the launch so that we make an extra effort to make sure that everything is really going to be just right so we don't have any failures.

SLADE: So you have 100 percent requirement for launch.

FAGET: A hundred percent requirement before it moves out to the pad.

SLADE: I always think it's a miracle it gets off.

FAGET: Well, anyway, that's been a contributor to it, that and some other things. There's all sorts of stories that confirm this. Some time ago, the mechanism that hooks up the ducts, the big fuel-carrying pipes between the orbiter and the tank, in all of the mechanical aspects of this, the tank's just more or less the passive partner in this thing. The motion of the thing, the retraction, and all that, is all done on the orbiter side, as you can imagine, because that's the complicated [part and should be recovered]—probably they'll throw away the tanks, so we make that as simple as possible. One of these ducts started leaking on one of the orbiters, and we got to looking into the records, and that damned duct had been recycled something like a thousand times on something like twenty flights. [Laughter] I'm not sure of the numbers, but that's about the ratio. So there is an awful lot of effort, a lot of tests made on the ground that wear things down, and then they have to be replaced. So a lot of activity on the ground is destructive as well as helpful, so to speak, and, of course, that makes for more work as you fix things.

SLADE: So it's a complicated brute, and it's built on technology we've never had before.

FAGET: Well, the approach on an airplane—and this is the way it should be for a reusable vehicle—the thing lands, they had a good flight, consequently, everything worked. Now, the things that didn't work, they go on your list, your maintenance list, but everything else that worked, you leave alone. But we don't do that. Everything gets rechecked out. We've got to get out of that habit, because, like I say, we've got four levels, and if you don't bother to check it out and you find out when you get ready to launch that one of them isn't working, well, you shrug your shoulders and fly anyway. That's the whole idea of having four levels.

SLADE: You're speaking of a different approach in terms of philosophy, a different approach in terms of saving—

FAGET: It's an ultra-safe philosophy, and, of course, that ultra-safe philosophy didn't stop us from moving on. It didn't have anything to do with it. [Laughter] We check out all these things because they're there and we can check them out. The things that are hard to check out, whatever, the flying things, they're the ones that are going to fail. The things that worked last time, as I say, are going to work this time, so you don't have to check them out.

SLADE: When you left NASA, you went to start your own business building a small space facility, an independent space facility. What happened there? Tell me about this. What went along?

FAGET: It was a good idea. Actually, I think it was a wonderful idea. The basic idea was that we built something that could be launched on the Shuttle that had a pretty good amount of volume. I forget what the volume is right now, but it's a good amount of volume, but it was completely capable of doing everything. Nothing had to be added to it. Bring it up to orbit, turn it loose, and it would work for 30 to 90 days or maybe 120 days, you go up and rebuilt it, resupply it, leave it up in orbit, and the thing would work. So it was a man-tended facility.

It had an internal volume that was kept pressurized. Man can enter it. They would live off the life support system on the Shuttle simply by transferring air between it and the Shuttle, so we didn't have to put a lot of life support system in there, and when you wanted to make it bigger, you just add another unit to it. The units were designed in a manner that what you use them for—sort of like a Quonset hut. You can use a Quonset hut as a barracks, you could use it as a place where you prepared the food, or you could use it as a repair shop. They are used all these ways, and they are easily erectable. Well, it's the same concept.

We took the viewpoint that you want to go into space, it's sort of like forming a beachhead anyplace. You don't go in there with the idea of building high, multi-story buildings, first-class buildings. You go in there with putting down enough to support a landing, a beachhead, and then you build from there. Well, it's the way we explored the frontier here. We had small cabins and we built up from there.

So after two or three launches of this thing, you'd get out onto it, and each one would be independent of the other, which had a pretty nice effect, you know. The thing about putting men in there permanently, if one of them failed, you just move into one that didn't fail, because they were independent and self-sufficient, but you could equip one with a life support system in it that would clean air for all the others and so forth and so on, and you could get up to maybe about six or eight of these things all attached together, and you'd have the equivalent to a Space Station. You would do it where, after the first launch, you're being productive, so you would grow at the same time you would produce it. It's a great idea.

SLADE: So what happened?

FAGET: Well, obviously what happened was that NASA had plans for a Space Station, and if this things ever got up there and we started adding onto it, people would say, "Why do we need the Space Station? Why don't we just keep going this way?"

SLADE: Is that kind of thinking—

FAGET: I'm simplifying your question.

SLADE: I understand.

FAGET: But it represented a threat, a major threat to the continuance of the Space Station Program. It had to be killed, and they did kill it.

SLADE: Through your customers?

FAGET: NASA and Congress killed it.

SLADE: Is it that kind of thinking and that kind of super caution that developed following the Apollo Program that caused you to make the decision to leave the agency?

FAGET: No, I left the agency—I was sixty years old when I left. We'd just finished the Shuttle Program. I was kind of burned out, to tell you the truth; at least I felt that way. The Space Station Program got started during the last few years that I was there. There was numerous problems, particularly with the tiles and things like that on the Shuttle, that I involved myself in. I wanted to get those properly solved. I had very little to do with the early conceptual work on the Space Station. I could see that by the time the Space Station actually got finished, that I probably wouldn't be there anyway, and I just felt like, okay, they're going to do the Space Station. I haven't gotten involved in it. If I did get involved in it now, I wouldn't be able to be there when it's completed, so that would probably taint my decision-making or whatever. It certainly would make me a lame duck as far as the other people in the program are concerned, so I just felt I'd better get out of the way and let them do it. I could see that it was going to have a little bit of trouble, of course. So there didn't seem to be any big challenge for me in there, so I left. Like I say, I thought sixty was a nice time to leave.

SLADE: You had a fabulous, fabulous period of time to be here.

FAGET: Oh, yes, that's right. You could see Camelot fading into the fog. [Laughter]

SLADE: Go over the characters that lived with you in Camelot. Who stands out most in your mind as the big movers? You've mentioned Robert Gilruth many times.

FAGET: Gilruth, Caldwell Johnson, [Joseph G.] Guy Thibodaux. I never talked about the spacesuits. Dick [Richard S.] Johnston and some of this companions, as I told you, they did the spacesuits all in house. That's the one thing that did not have an NACA heritage. It had a Navy heritage. Dick Johnston came and introduced himself to me shortly after NASA got formed and we had the program on the way. He said, "You need somebody to worry about spacesuits for you."

I said, "I sure do."

So he said, "Well, how about it?"

So we took him on, and then he went back to where he had been working. He'd been working for the Navy in Philadelphia, where they had space—well, it was a pressure suit laboratory.

SLADE: For deep diving?

FAGET: No, no. For high-altitude aircraft, pressure suits, partial pressure suits, and they were looking at full pressure suits. So he recruited some of his good friends there, and we ended up forming a very good team of people in that group, and they still are a good outfit at the Center.

We ended up being able to—you know, when we started the Apollo Program, the requirement was to leave a man out for a couple of hours, so they had to have a backpack that would do that. On the last mission, they actually had three working days, three eight-hour days, out, which meant that backpacks had to be replenished in between, and they had to be good for an eight-hour day, plus they carried emergency oxygen that never was used on any of them.

SLADE: Look how fast that technology snowballed, though. Look how that happened so quickly.

FAGET: We pushed hard. I mean, there were eager people working on it, people with vision and people who were just competitive as hell, wanted a challenge and wanted to work.

SLADE: We've only touched on computers tangentially here in this discussion. The Apollo computer weighted ninety-three pounds and it had very small memory in comparison to today. We also talked about a tidal wave, a momentum. Aren't we still riding on the crest of that wave in terms of the technology that was sprung out of those intense ten years?

FAGET: I think to some extent we really are, but in many areas, particularly in the computer technology, we're no longer the leader. The commercial computers evolved ever so much faster than either NASA or the DoD can evolve their computers. Consequently, we're living off the thing that perhaps we had a tremendous impact on starting it—

SLADE: We'd been the driver.

FAGET: Yes, the early driver. Now we're hanging onto the tailgate. [Laughter]

SLADE: Don't we always do that?

FAGET: I think that's good. I think it's good. But that's typical of what's going on. I think a lot of the things that are happening in medicine underwent the same thing. During the very early days, there was a tremendous lack of capability to make measures on people's good health. So we pushed hard on that and were very creative in doing that. But then finally those things got shifted over in to people who are not in good health, and that created a revolution within the medical industry right now, that you've got all sorts of laboratories that have engineers working alongside of doctors creating new procedures, new things, and so forth, the use of the laser and all sorts of things that they can do now that were absolutely impossible.

SLADE: Correct me if I'm wrong. Didn't the physiological monitoring system that went into the early spacecraft, didn't that become the basis for the intensive care system installed in hospitals?

FAGET: Yes, that kind of instrumentation. When the hospitals saw that that was available, they jumped on it. See, no one had ever done it before to the extent that we did, and when they found it, "Oh, gee. We can use that." So they did it. It was not a direct spinoff, by any means. It was just the fact that it opened people's minds into possibilities, as much as anything else, plus the fact they could get prototypes, you know, and say, "Well, this is not exactly what we want, but I can see this is a seed for what I need."

SLADE: So those ten years, those amazing ten years—

FAGET: Big ten years. Well, you look at World War II, it did the same thing, see. All of our jet transports were spawned during World War II. Right after the war, the military had to have jets, because that was what the enemy was going to have. So we all worked like hell on those jets. But then the jets got transferred to passenger airplanes, and, lo and behold, a jet engine's a lot more reliable than a piston engine, many times more reliable.

SLADE: But you were there. You were there in all of it.

FAGET: Yes.

SLADE: Fantastic. Well, let's sum up. You're a big fan, and you have the spark, and people stay with this agency for years because they have the dream about it. What's the object? Why go to space? Do we go for practical business reasons, or is there something more important lurking there in the background, in your mind?

FAGET: Yes, I think so. I look at my life, and when I look at the way I approach things, everything has been a toy with me. My toys were things that worked, things that flew, dove under the water, little race cars. I always liked things like that, and it was just a hell of a lot of fun to make these things work. And then I grew up and my cars got bigger, more interesting, and I still like to play with toys. So I think the world will always have men that never grow up, that will do things that didn't seem to have a hell of a good purpose at the beginning, but turn out to be innovative and useful, for reasons that no one ever dreamed of. So that's the way it goes.

SLADE: Good for you. Thank you, Dr. Faget.

FAGET: You're welcome.

SLADE: These interviews were done with Dr. Max Faget at the Johnson Space Center over a two-day period from June 18th, 1997, through June 19th. The course of the interviews lasted something on the order of five to six hours.

We appreciate your coming here and joining us. This is a remarkable contribution, and your life has been that kind of contribution.

FAGET: Well, it's been a lot of fun talking to you, too. Thank you.

SLADE: The interviewer was Jim Slade.

[End of Interview]