NASA HEADQUARTERS NACA ORAL HISTORY PROJECT
ORAL HISTORY TRANSCRIPT

EDWIN C. KILGORE
INTERVIEWED BY SANDRA JOHNSON
NEWPORT NEWS, VIRGINIA – MAY 3, 2008

JOHNSON: Today is May 3, 2008. This oral history is being conducted with Edwin Kilgore as part of the NACA [National Advisory Committee for Aeronautics] Oral History Project sponsored by the NASA Headquarters History Office. This interview is being held in Newport News, Virginia, during the NACA Reunion Number XII. The interviewer is Sandra Johnson, assisted by Rebecca Wright. I want to thank you for joining us today and allowing us to come into your home to do the interview. I would like to start by asking you to briefly describe your background and how you first became interested in aeronautics and wanted to study that when you went to Virginia Tech [Virginia Polytechnic Institute (VPI) and State University, Blacksburg, Virginia].

KILGORE: I first started at the Norfolk division of [College of] William and Mary and VPI, Norfolk [in 1940]. It's now Old Dominion University. In those days, they only had two buildings, and I was interested in mechanical engineering. While there, I worked at the J. G. Wilson Rolling Steel Door Company over in South Norfolk, and during the early parts of the war [World War II], while I was still in school, I was given a job at J. G. Wilson to design the rolling steel doors for the CV Class Aircraft Carriers.

At that time, I hadn't had any Strength of Materials [engineering class], so I set up stands out in the shop and loaded the design door, to the load [required by] the Navy. Navy came out and inspected it and okayed it, and those were the doors on the [exterior of the] aircraft carrier.

It may have been one of the [most important] engineering jobs I ever did, but I was still in my freshman year of college. I was quite proud of that at the time. [I won an American Society of Mechanical Engineering (ASME) award for a talk I gave at an ASME convention on the door design.]

Then I went on to Virginia Tech for my last two years, and while there, I was in the class with Bob [Robert F.] Thompson and Chris [Christopher C.] Kraft, and others who were key people both in NACA and NASA. They were part of the Cadet Corps, so they got taken out and sent to the war. Since I was civilian student coming from the Norfolk division, they left me in to finish, and when I finished, they inducted me into the Navy. I had about three months before I went in the Navy. So I said, "Well, I've heard of NACA. I don't really know what the acronym stands for, but I've seen all the work that they've done through some of [their technical] reports." I said, "That'd be a wonderful place to get acquainted with." So I went over, and that same day, they put me to work. I was interested in doing design work, so they put me in a design section in this—picture this building that I showed you earlier. It was a three-story building with shops down below. No air conditioning. It wasn't anything except it was a very intriguing, very challenging place to work.

I really enjoyed the three months I was there, but then the Navy called me so I had to go to Richmond [Virginia], and they put me on a train going to Sampson, New York for [Navy boot camp] training. I'd been on the train an hour or so when [a] Shore Patrol policemen came through, and said, "Kilgore, Kilgore!" That disturbed me. Nobody knew me from Adam. Well, he said, "We've got to get you off at the next stop, and we're going to send you back to Richmond, and send you back to NACA."

Apparently, the NACA had an agreement with the government; they needed technical people. What they needed was to get another five or ten miles an hour out of those airplanes to fight the Zeros [Japanese fighter plane]. Since I had already worked there for about three months, they decided they wanted me back. So they made an agreement with the Navy, and they sent me back, and they put me in the Air Corps, which is more appropriate to what NASA did at that time. It wasn't long after that that I was made head of the model group.

The model group was a group that was responsible for [designing] all the models, from the size of your finger all the way up to the size of full-scale airplanes. So we had quite a diversity of work as a result of this. [For example,] I developed a machine that would cut steel airfoils [for wind tunnel] models in order to take the increased loads as airplanes increased [up to supersonic speeds].

So that's the way I got started in NACA. A little later in my career, I got very interested in some of the things that we were doing on Wallops Island [Wallops Flight Facility, Virginia]. I had a group that designed [multi-stage] rocket-powered models. There were five stages, and we would fire three stages going up and two stages coming back in, so you went [through] transonic speed. And it was the only way, at that time, that we had any way of getting aerodynamic data [at] transonic speed. We didn't have any transonic tunnels. So we got [our first] data [at] transonic speeds from these models coming back into the atmosphere. So I got very interested in the missile work, the rocket work, along with the aeronautics in the model business.

Floyd [L.] Thompson, who was head of [NACA] Langley [Aeronautical Laboratory, now NASA Langley Research Center, Hampton, Virginia] at the time was an interesting guy. He [generally] never charged anybody with a specific task, he just challenged you to go do something. He challenged me to help [Langley] get into the space business. So I took it on

myself to instigate projects like Echo [satellite] and Scout [solid-fuel rocket]. I acted as the co-project manager for Scout [when it started].

Our objective on the Scout was to design a research vehicle that would reach orbit for about a million dollars. Well, of course you wouldn't even think of that today. But we came close to doing that. For about a million and a half, we developed four of them. Three of them went into the swamp [at Wallops Island out of control]. But we found the problem, and the fourth one made orbit. So it was the first four-stage, solid-fuel vehicle in the world that made orbit, and it was used for years after that as a cheap [reliable] vehicle for research.

Ling-Temco-Vought was the contractor, and they made a lot of money by selling it. The Italians got into it in a big way, and they built a station off of the coast of Africa in order to get an equatorial launch [using] the Scout. So it had quite a history after that.

So then, to go on with my career, I was asked to go to [NASA] Headquarters [Washington, D.C.] and be the Deputy Associate Administrator of OART [Office of Advanced Research and Technology], and Langley was one of the Centers that belonged to OART. [NASA] Lewis [Research Center, Cleveland, Ohio] was another one, which is now Glenn [Research Center], Wallops Island, [NASA Dryden] Flight Research Center in the desert in [Edwards] California [and Ames Research Center in California].

So while I was there, a fellow named Roy Jackson, who was a Vice President of Northrop [Corporation] at the time, agreed to be the Associate Administrator over these Research Centers for a period of two years. I never knew about his two years at the time, he was just a very [exceptional] boss and a very ingenious kind of guy, and even some of the aeronautics programs that are being worked today came out of the program that he put together. For example, the [V-22] Osprey, the tilt rotor [aircraft], that all started out of a program that we started. He went into

[pushing] the Centers into more systems research. Things like the tilt rotor would end up being a useful [end] product, [as well as greatly accelerate the development of new technology].

A lot of the researchers rebelled at this, because as you get to be an expert in a field like aerodynamics, or anything else, you get to know more and more about less and less, and you get to be an expert in that. You get to go to these conferences all over the world, and you make speeches and all this. Well, Roy Jackson [wanted to make a more meaningful impact]. We needed to awaken the system a little bit and get [researchers focused on the most immediate aircraft technology needs].

I was also able, at the time, to get some of the people interested in space, and some of them came in kicking and screaming. They didn't want to leave, they were expert in something here, and here they're going into something entirely [new]. There were a lot of doubts about what happens if you go into a space program. Of course the Lunar Orbiter [and the Viking were] like this. I encouraged a number of the people, including my deputy at the time at Langley, to go into [these projects]. [Fortunately], they ended up as very successful programs.

There was one other thing that I omitted in telling you as to what Langley was when I first came there. Langley was totally different from anything that I guess I had expected. I'll take the example, Bob [Robert R.] Gilruth. Bob Gilruth was head of [NASA] Johnson [Space Center, then Manned Spacecraft Center] for a number of years. He was head of the Flight Research Program [at Langley], a very bright guy. I used to play tennis with him while he was [at Langley]. He was one of 10,000 people who took the Federal Service Exam for a job at Langley, and he's the one that got it. That's a pretty highly selective method of getting a job. [Many] of the [Langley engineers] were of equal caliber.

One fellow, for example, [who] was head of all the [supersonic research] programs in Italy [during the war was helped to escape and brought to Langley]. Of course, at the same time they got [Wernher] von Braun and brought him over to work the Missile Program. But it was a highly selective program, and we were all known as "Brain Busters" by the [Hampton] locality, and the locality didn't have too much fondness for the Brain Busters. They were a little different, we were different people, and it took a long time for them to really accept that as a part of the community. Of course, it was economically a very big part of the community, because the NASA Research Center had 1,000 people and they contributed to the economy here.

Shortly after, my former wife Ann was elected Mayor of Hampton. At the time, there were only 25 or 30,000 people, a very small village type of thing. As she was involved in politics and being the Mayor, it grew to over 100,000 people, so it was a rapid, very rapid growth, and she was very interested. That was her baby, Hampton. So the people not only accepted the people at NASA, we became a part of the community and a part of the leadership of the community. So that's the way Langley got and the way it is today. It's not only accepted, it's a part of the community.

JOHNSON: During those first years, I want to go back to that and maybe touch on some of the details of that. You worked here for three months, as you said, for a while, and then you got on the train thinking you were leaving. Did you have any idea that they wanted to bring you back, or was that a surprise to you?

KILGORE: No, I had no idea. It was a great surprise to me.

JOHNSON: When you first started working, you were in that area where you were making models?

KILGORE: Yes, I was in a model group. Matter of fact, it was headed by Caldwell [C.] Johnson. Caldwell Johnson and Max [Maxime A.] Faget are the fathers of the Mercury, Gemini, and Apollo, the design of those vehicles. [Johnson] was one of the best designers that I've ever really seen, and Faget, he was the dreamer. He was the guy who saw way ahead what needed to be done. Caldwell Johnson made the designs and put it into hardware. Now of course all that was [eventually] contracted out [to be developed], but the basis of it all came from those two guys. I was put in [Johnson's] group when I first came here. Well, shortly after, he was taken out and given another job, and they gave me the group.

JOHNSON: How much experience did you have as far as making models, and how did you learn that? Was there some sort of training that you went through, or did you just start working?

KILGORE: Well, I learned a lot from Caldwell Johnson. I got to work with him about three or four months, and in that short time, believe it or not, I got to learn a great deal about models. But the model business changed dramatically, because as the speed changed, we had to have stronger and stronger models, and I was able to develop plastic fiberglass models, which were not only stronger than the wooden models they'd used before, but they were a lot easier to make. So the wood shop became the plastic shop, really.

The other thing we did as a model group was that all the propellers for the wind tunnels around the world were all made of wood. The problem with it is that if anything [broke] loose

and went down [the tunnel], it just tore [out] a whole set of blades. These blades were whirling, and this [loose projectile] went through there and just tore the whole thing out. So I decided that we needed something a little more substantial. So taking the experience we had with the fiberglass models, we developed a fiberglass wind tunnel blade, and we put it in the eight foot, high-speed tunnel, which was run by Dick [Richard T.] Whitcomb [of area rule fame]. But anyway, it was put in as one of the blades and all the rest were wooden blades. I got a call one day [which] said, "All the blades came out," and I said, "Uh oh, here goes my job." It turned out when I got over there, there was this plastic blade standing up there like a new penny, all shiny, not a scratch on it. So all the blades since then in wind tunnels around the world, practically all of them are made of fiberglass.

JOHNSON: What caused all the other blades to break at that point?

KILGORE: Well, they're wooden, they just shatter when something hits them.

JOHNSON: Oh, so something hit them.

KILGORE: Yes, it was like a baseball bat. You hit it too hard, it breaks, shatters. But the fiberglass was very resistant. Matter of fact, they make bulletproof vests and all this out of that kind of material. Not exactly what we used. So it was a very interesting time, and a lot went on.

I was at an advantage in running the model group in that I got to see aeronautics, I got to see subsonic, supersonic, and hypersonic aerodynamics, because we were making models for all these people, so you had to understand the load, you had to understand what happened to it as

much as we could at the time. That was one way that I got a very broad aeronautic background. Then, of course, I got interested in the space business by Floyd Thompson prodding me a little bit.

Bob Gilruth asked me to go to Houston with him when the [Space] Task Group went to Houston, but my wife was Mayor [of Hampton, Virginia] at the time, and I was very interested in getting this space activity started at Langley, so I stayed there, and I'm happy that I did, in a way. But a couple years later, I went to Headquarters [to] OART. Later I became the Associate Administrator for Management Operations, with [institutional] responsibility for all the Centers. We had ten Centers at the time.

JOHNSON: In those first years, World War II was still going on when you joined the NACA, and shortly, a couple years later after the war ended, the things you were doing research on, did they change as far as did you start working more with commercial ventures than DoD [Department of Defense]?

KILGORE: Well, that's right. See, I came in '44, which was getting close to the end of the war, and we were still fighting hard, as I said, to get another five or ten miles an hour out of the airplanes to fight those Zeros. After the war, the commercial companies were very interested [in NACA research]. We had an advantage in those days, which NASA doesn't have now at Langley. Now everything is [considered] proprietary. Boeing [Company] is [reluctant] to put a model in a wind tunnel at Langley, because they are obligated to make that data public. Then Martin Marietta [Corporation] gets a hold of it, and then everybody else in the world gets hold of it, Airbus and so forth. That's the way that the government is set up.

So Langley can do basic research because it's available to everybody, but they're highly constrained as to what work they can do for Boeing or what work they can do for Martin or so forth. That wasn't the case back in [the early] days. Aeronautics was still in its infancy, commercial aeronautics in particular. So everybody climbed on board. People were tickled to death to have their models put in the wind tunnels, and then the data was distributed everywhere, but the big companies [used the data and prospered]. The Boeings and so forth, they all came out as the upper-most companies in that field, because they used the data more wisely than other people did [to make better airplanes].

But that's kind of a major difference between aeronautics program of today and the aeronautics program then. The aeronautics program then was the aeronautics program for the United States of America. There were a few others that were contributing pieces here, but NACA was it. You learn in management school, anywhere you go to management school, that you can't run anything with a committee. Committees are terrible. But NACA was probably the best-run organization that I ever worked for. NACA was run by a committee. It was the National Advisory Committee for Aeronautics. It had people like [James H.] Doolittle and Orville Wright and people like this, [Jerome C.] Hunsaker, the real pioneers in aviation, on the committee.

The other reason it worked is that they only met once a year, and they reviewed what Langley and what Lewis had done, and they decided that, "Well, that's very good, but we need to do this and this and this." They were reflecting the views of the aeronautic community for the whole United States, and we're missing that just a little bit. No, we're missing it a lot now. But my point is that that was run by a committee, and it was very successful and the best-run organization that I know of.

There was very little bureaucracy in Langley. It was all done by a handshake or a phone call or whatever it was, and that, of course, changed a great deal under NACA. When I finally went to Washington, you didn't do anything without two or three memos, and it's probably true in every Center including Johnson now. This is what you do. People were encouraged to go off on their own, with people like Floyd Thompson as the Director, and do things, do innovative things, do something you're not [even directly] responsible for. If you can make a success out of it, we'll create a whole [new] organization that's that way. So it was the premier research organization for aeronautics in the country, and primarily because it had very little bureaucracy and it was run by a committee of wise people who said, "This is what you should do, this is what aeronautics needs."

JOHNSON: I've noticed in the other interview, I heard you mention that you worked on the full-scale tunnel, the redesign of the scale system. You want to describe that for us and give us some details about what that entailed?

KILGORE: That was one of my first jobs when I came into Langley. The full-scale tunnel system needed some innovation. Well, one thing, the the loads were higher and the scale needed to be changed. But we also needed a way of changing models, models being full-size airplanes in that case, more easily. So what I did was design a system that had movable plates and rotating plates, so that you could accommodate different airplanes and attach them to the scale system down below.

Now, that was all very nice, but it wasn't too long that it was all changed, because strain gauges came in. With strain gauges, you could measure all these forces on models and all

without having beam balances [with their inherent problems]. You had to let them settle out. It was like you get on a set of scales, and the hand wavers a little bit, the pointer wavers a little bit. Well, you had to wait for all that to settle out. They had some [pressure measuring manometer] tubes, you had to wait for those. But the sensor [data] systems improved probably more than almost anything in research in a period of four or five years after I came in. Electronic sensors, strain gauges, those kinds of things. We got probably ten times the amount of data per unit of time that we did with the old scale system, [which was essentially obsolete even with the redesign].

JOHNSON: You mentioned the technology changing. While you were there, over your years, the technology changed quite a bit as far as things like the different systems, but also computers. When you first started there, how much interaction did you have with the female computers that were there to do the math calculations?

KILGORE: I had a lot. We depended on them for those Friden calculations. They didn't have any computers other than the Friden, but they did all of our calculation. In the model work, for example, when I came in they had no way of translating [airfoil coordinates] The wings were straight generally, and so it was easy. Airfoils were in the air stream direction of the wing. But when we got into swept back wings, then the airfoil was diagonally across that. We had to have some way of translating the airfoil sections into [stream wise coordinates]. So I worked out a [formula] to do that, [which] I gave to the computers, and any time that we made a model, a swept back wing model, they figured out the coordinates for the wing. They were very good at it.

Of course, now this formula I worked out is all computerized and in a matter of a few seconds, you've got the answer, where it used to take them a half a day going through to get the answer. So everything here has changed dramatically, mostly because of electronics. See, in my lifetime, [I was] very lucky, because almost everything except the printing press and the steam engine were invented in my lifetime. Now, the car came out a little earlier, but really, it never got to be—I was born in '23—it never got to be many cars that people rode in until after 1923. It's a very unusual time to have lived, and I'm very happy, looking back, to have had that opportunity to live at the right time. I didn't have anything to do with it, but it was there. [My generation was fortunate.]

JOHNSON: While you were there, and of course you were still with the NACA, Sputnik [Russian satellite] launched in 1957, and things began to change somewhat. Can you describe what, once that launch took place, were you working on at that point in your career and how did that change? Or did it change at all after Sputnik?

KILGORE: Well, at the time, I was personally doing a lot of work on Echo. Echo was intended to be a communication satellite, and you'd put up a number of them and you'd bounce the signals off and back down to the Earth. Because nobody believed that you could make electronic equipment that would stand the rigors of space. Well, that turned out to be folly. Of course, now we not only do that, but we do a lot more with it. So the main thing that came out of Echo, the big thing that came out, was everybody in the world could see it. So that really was the first competitor that we had for Sputnik. Everybody could see the Echo. Sputnik, they could hear it beep, but that was about all. There was a lot of doubt about whether the thing was really beeping

or what was happening, but Echo, everybody could see it. So it turned out to be a real godsend, from the country's standpoint, and it wasn't intended to be that at all.

JOHNSON: What were you working on with Echo as far as what were your duties? Were you helping to develop the design?

KILGORE: Yes. Well, as I said, I developed the first sub-satellite using this Mylar material, and the problem was getting it scaled up to 100 feet diameter and put into a small ball. I remember the problem we were having with folding it. If you ever tried to take several acres of Mylar, which is kind of flimsy, and fold it, it just wants to go here and there and everywhere. So it was a real problem.

I was home one rainy morning, and I was getting ready to go to work, and my wife took out her rain hat. You've seen rain hats, you just flip, and they come into a very neat [strip], and you unfold them and they come into a hemisphere [to fit] your head. I said, "I've got to have that." She says, "I need it." I said, "No, I've got to have it worse than you." So I took this out and I gave it to one of the guys down at the shop, and I said, "Look, you go out to the company that's building this Echo balloon, and you take this and you make some forms out of plywood, and make it a real orderly process so that it will look just like this rain hat." That's the way that the thing got folded.

They were having trouble. They had it in a room and they'd push one end, and the other end would go out the other door. They couldn't even get it in a room. We had to get it into a 19-inch [diameter] container. Well, we ended up folding it so tight that we had to put spacers on the inside. That was quite a folding job as it turned out. The reason it had to be folded this tight was

that if it had air on the inside, residual air, left inside the balloon, it would blow up the minute it was exposed to space. The first one did.

We had a trial balloon, so to speak, in which we fired a rocket going up and then the rocket coming back down, and on the way down it released the capsule and the pyrotechnics fired to open the capsule, and the balloon came out. But what came out were just 10,000 pieces of confetti. It had all this residual air in it, [which] just blew it all to smithereens. It doesn't take much in a vacuum to blow things up, and this, of course, is [a] fragile material anyway. So we had to get the residual air out of it, and that's the reason that it's packed in such a tight space.

But that's essentially a long way of answering your question [as to] what was I working on at that time. That was one of the things I was working on, trying to solve that problem. But we had the Scout that we were working on. We had a lot of those projects that were related to space at the time.

JOHNSON: From what I've read, there was a lot of excitement, as you mentioned. People could see Echo once it was launched successfully, and there were some attempts that failed, obviously. Once it was launched successfully, President [Dwight D.] Eisenhower sent a message. Do you remember that moment, or do you remember hearing that and knowing that it was coming from space?

KILGORE: Yes.

JOHNSON: What was the feeling at that time?

KILGORE: Those of us concerned at Langley with the space activities were euphoric. The aeronautics people weren't [overly] happy with anything having to do with space. I'm not talking about all of them. But many of those, if you attended the [NACA reunion] last night, many of those sitting in that room didn't want anything to do with space. They were all aeronautics, and that's their life, and [they wanted] to continue that. It's very difficult to get some of those people to change horses, but some of them did, and some of them became very successful in doing that. People don't like change. You probably know that yourself.

JOHNSON: What made you want to go into the space side instead of staying with the aeronautics side?

KILGORE: It was all new. I mean, it was totally new. We were really pioneering. I was working with what will be considered in future years the space pioneers. Guys like Chris Kraft, we were all the same age, all working together, all feeling our way along. There were no classes in schools that taught you the things and the problems that you were going to end up in. Bob Thompson was my doubles partner for years in tennis, and we won a lot of tennis tournaments, and [he] became the [Space] Shuttle Project Manager. He didn't take anything in school that told him how to be a Shuttle Project Manger, or even how to build a Shuttle. But we all just kind of felt our way, and those people will be known as the space pioneers in future generations.

Bob Gilruth certainly was a space pioneer. He had a lot to do with pushing it. I rode back on the NASA airplane from Houston to Washington with Bob Gilruth in the latter years, and he said, "Ed, I'm going to Washington to try to stop the manned space program." I said, "What the heck are you doing that for? You've made the cover of Time Magazine, you're a hero

to the Americans." He said, "Well, you just don't realize what would happen if we ever have a catastrophe in which we lose astronauts." Well, anyway, he didn't have his way with the powers that be, and he was lucky. We all were lucky.

Every one of those Moon landings worked. It was in the latter days, with the Shuttle and the [Space Shuttle] *Challenger* [STS 51-L accident] and so forth, the press has gotten into it, and any time you have a failure like the *Challenger*, of course the press is going to make a big deal out of that. Now, if you have a success in going to the Moon, you get very little publicity out of that. So Bob Gilruth was right. I didn't realize what would happen.

I was playing in a tennis tournament down in Florida, and somebody came up, knew I worked for NASA, tapped me on the shoulder and said, "The *Challenger* has had an accident." Well, I stopped playing, went up and listened to the TV. But first thing I thought about was Bob Gilruth's prophetic words. If we ever have that, you can't realize what's really going to happen.

When the Apollo 13 [accident] happened, I was on the investigating committee for that, and I'm not sure that we, as an investigating committee, would ever have found the smoking gun, the absolute thing that happened there. But Rocco [C.] Petrone, who was head of the project at Houston, we gave the task of trying [with his project people] to find out what happened. Well, they mocked up the oxygen tank, you know, it was an oxygen tank that exploded. Fortunately, it exploded outward. If it had exploded inward, we'd never heard from them again, but it exploded outward. Rocco and his troops mocked up the oxygen tank, and they found out within a matter of a couple weeks that it was a little thermal sensor about the size of your thumb that was underrated.

What it was put in there for is [that] on the pad, the oxygen tank [periodically] needs to have some heat in order to keep [the oxygen liquid], and so the [tank] thermostat was supposed

to tell it when to turn the heat on. Well, it did, but then it welded shut because it was underrated. Some electrical engineer somewhere along the line just didn't do the job right, and it's that little simple thing. You could have bought that in a hardware store, probably for five dollars. But it [eventually] cost the country one heck of a lot of money.

My point in all this is that since the press, the government and [the public have] gotten into all these failures, they try to exclude the [project] people who work on it. Well, that's folly. We [may] never have found [the Apollo 13] problem, if it hadn't been for Rocco Petrone and his group who mocked [up the oxygen tank] and found it.

The *Challenger* accident. Well, they had a bunch of people on there who were high-powered people, but [they generally lacked engineering competence]. They had some high-powered scientists. In retrospect, they should have had NASA people who actually worked on it, but see, they were afraid of a cover-up. When you get in Washington, you realize how much people think in those terms, a cover-up kind of thing. That's not in the culture of NASA. The culture of NASA has always been, in my experience, to find out what went wrong, correct it, and go ahead. In the *Challenger*, if they had let the project people get in and find out what was wrong, they could have fixed that in a matter of six months, and a year later been flying, at one hundredth of the cost. Well, I got way off the subject, but anyway.

JOHNSON: That's okay. Let's go back to when you said earlier that Floyd Thompson asked you to coordinate the activities there at Langley for the Space Program. Do you want to describe exactly what he was asking you to do and what you did to coordinate those activities?

KILGORE: Well, Floyd was never very specific. Matter of fact, he probably had other people in his office just after me, one I know of, John [C.] Houbolt, he told the same thing. "We want Langley to be a player in this space program, and we want it to be a major player in the space program, and see what you can do to push the people into that direction." I'm sure he talked to half a dozen people with that same story, and a half a dozen people responded, and they in turn got many, many more people responding. The ones that didn't were the diehard aeronautics people, "We are not going to work on space, we are going to work on aeronautics." I had a little bit to do with maybe unraveling that, when I went to Washington with the Centers to get it a little more oriented toward the real world and a little less toward just calculating, speculating. Well, anyways, that's another story, too.

JOHNSON: So you helped coordinate. Did you go to some of the other Centers to help coordinate that with Langley? Did you visit other Centers and help to pull people in?

KILGORE: Yes. I went to, of course, a lot of meetings. We were talking at the time, on Echo, we had to fit the Echo into a launch system, so I had a lot of dealings with universities, a lot of dealings with the aerospace companies, and a lot of dealings with the other Centers, because the other Centers, even on the Scout, the Johnson Center—well, I had a lot of dealings with Wernher von Braun and his people at the time. As a matter of fact, Headquarters wanted to transfer the Scout because—this was before NASA—wanted to transfer it to Houston. So Thompson sent me down to Houston to talk to von Braun about it.

Well, von Braun had this conference room and welcomed me graciously, and he had all of his head-knockers sitting around the table, and behind them was their American counterpart—

all [the principles were] German that time, and behind them were their American counterpart. When I made my presentation as what a great system this was, how cheap it was, what all this could accomplish, he said, "Well, I don't think this is quite the scale of the thing we are going to be doing here," and he said, "But we'll take a vote on it." Well, they went around, you know how that came out. That was unanimous. So I went back with my tail between my legs, and the Scout stayed at Langley throughout its history, [which in retrospect was a very good decision].

JOHNSON: The Scout Program, you were using off the shelf products. Is that correct, to create the Scout?

KILGORE: The first stage was a new contract. The second stage was a military missile. And the third stage was a military missile. The fourth stage was a new contract, so half of it was military missiles, and half of it was new.

JOHNSON: You actually worked with the contractor and had a long relationship with LTV Missiles and Electronics Group of Dallas that worked on the Scout?

KILGORE: Yes.

JOHNSON: What was that like, that relationship of working with a contractor developing that program?

KILGORE: Well, at times, it was a little testy, because we had lots of problems. First of all, we were new in project management of a major system like this. We learned as we'd go along. A fellow named Bill [William E.] Stoney [Jr.] was a co-Project Manager with me. I handled all the contracts and all the business arrangements, and he handled all the trajectory work and all that. I've lost my thought, I'm sorry.

JOHNSON: That's okay. We were just talking about working with the contractors and how difficult that was at times.

KILGORE: It was a lot less difficult in those days than it was later on. They were willing to do almost anything to get in the business. For example, the contract that Ling-Temco-Vought gave us for the Scout, I'm sure it cost them twice as much to make the first Scout as what they got out of it, but it was worth it to them. They made it up later on because of repeat business. This was true of most of the companies in those days. They were perfectly willing to take a chance at very little dollars just to get in the business and establish their place in the space market.

JOHNSON: The STG [Space Task Group] was forming during that same time period, and you mentioned that you were asked by Bob Gilruth to join it, but you decided to stay. When you stayed, what were you thinking you were going to be doing, and how did your career follow after that time before you went to Headquarters? What positions were you in at that time?

KILGORE: You see, as I said, the decision was partly personal, because my wife was Mayor of Hampton at the time, and she loved the job. She'd done a lot to build the city up, and I couldn't

see pulling up stakes. I was perfectly happy at Langley. Matter of fact, I felt that I could contribute more by being at a broader scope. That is, dealing with more space projects than just Mercury. Well, there was no Gemini and Apollo, it was Mercury at the time. But the guys who left, Bob Thompson, Kraft—they became the leaders of that program and they did a bang-up job with it, no question about it. It would have been an interesting career, totally different from what I had. But in Washington I got to play probably a bigger role than I would as a part of Houston, as the Associate Administrator.

JOHNSON: Did the other employees you mentioned, the aeronautics people that didn't want to have anything to do with that, was there a general feeling that when people were moving on and going into the space program, were people worried that aeronautics was going to shrink and that their jobs were in danger?

KILGORE: Well, they almost intuitively knew it was. There was a question of when, it was just going to happen, because there's only one pot of money. Of course, the pot of money increased dramatically. I was in a meeting with [James E.] Webb, who was the second [NASA] Administrator, but the one that really started the Apollo Program. And he said, "I got a call from the White House." Webb had been head of the Bureau of the Budget, and he'd done everything in Washington. He knew everybody by a first name basis, and he was the perfect man to be the Administrator of NASA at that time, because he had all kinds of influence. When you heard him testify before Congress, you would have thought he was the world's renowned scientist. He was a lawyer, but he picked up on stuff very rapidly, and he could sell a bill of goods to almost anybody.

But anyway, to go on with my story, he said, "I got a call from the White House, from Jack." [President John F. Kennedy] He called everybody by their first name, he knew them all by first name. He said that Jack said, "Look, I want to go to the Moon."

[Webb] said, "Well, that probably could be done, but I'm not sure we should."

[Kennedy said,] "Look, I want to do it."

[Webb] said, "Well, if you want to do it, we'll do it. I'll do it under one circumstance. You go with me over on the [Capitol] Hill, and we'll talk to the majority party and the minority party in both the [U.S.] House [of Representatives] and the Senate, and so if they all agree, then I'll do it."

He says, "Of course, I would have done it anyway if he said go do it."

He went over on the Hill with Jack Kennedy, and they did just what he said. He met with every one of them. So what he ended up with was a blank check, you know, anything he wrote in terms of a budget. When they brought the budget to him for the Apollo, he said, "I looked at it, and I doubled it right there on the spot." He said, "I thought about it overnight, I doubled it again. It turned out to be about right." So I always tell people that if they're in the estimating business, pay a lot of attention to that story.

JOHNSON: During NACA, they had their annual inspections, and you had visitors that would come, and then when they were moving into the Space Program, of course, the astronauts were training at Langley. Can you talk for a moment about maybe some of the people that came to Langley that you remember, or anything special about any of those inspections?

KILGORE: Of course, the [NACA] Committee came. Hunsaker, Doolittle, Orville Wright—this type of people. And they all went over to the full-scale tunnel and they arranged seats over there, and they all had their picture made, and those pictures are quite historic in terms of the people who were there. Of course, I was a young engineer, and I was lucky to get to go look in and see them have their picture made. That was about the extent of my participation in those days. But that was a part of their being briefed on what had happened the year before.

Langley put great stock in not only writing reports that were not only readable but were accurate and were helpful in whatever field it was. A fellow named [W.] Hewitt Phillips was Chris Kraft's boss, and Chris still gives him credit for his success in his career, and Hewitt Phillips kind of wrote the book on what reports should look like in NACA. In other words, to be readable, to be accurate, and to have somebody want to read them—that they've got something in there that they want. So everybody kind of followed this mold from then after. Tell me your question again.

JOHNSON: I was asking about some of the people that had visited Langley during that time period.

KILGORE: I was saying that—also Langley put great stride and a lot of work into these exhibitions, as I call them. Inspections, they called them. The different research organizations were asked to come up with their best innovation of the year, and to be able to present it in a concise and interesting way that people like Doolittle and all would raise their eyebrows, "Yeah, that's pretty good stuff." It turned out to be that way. They got very interested in it. So Langley was one of the few government agencies in probably all of history that got more money from the

Congress than they asked for every year. We'd love to be in that position today. But we'll never be again.

That was a very effective way of keeping up with what was going on in the NACA. The other Centers came in, and at times the inspection would be at Lewis [and Ames], and at times it'd be at Langley. They [would] alternate them so that this Committee and all the other dignitaries got a chance to see the Centers, meet the people, and hear about the [NACA research] program. Because a lot of Congress was there, too, that was one of the reasons we got more money than they ever asked for. [They wanted NACA to] "do more."

JOHNSON: What about the astronauts when they were training? The early Mercury astronauts—did you have any interaction with them?

KILGORE: Well, I didn't have a whole lot of dealings with them. They were over on the east side, NASA Langley was primarily on the west side [of Langley Air Force Base]. I started out on the east side, then everything moved to the west side of the landing field. So Bob Gilruth took all his people and went over to the east side again, and that's where the astronauts were trained. Now, I met a number of them through being the husband of the Mayor, but that was about the extent at that time. Later on, I got to know all the astronauts pretty well. Matter of fact, Neil [A.] Armstrong and I had adjoining offices while he was in Washington for quite a while. Interesting guy, he's very intelligent, but he's not an outgoing kind of guy, and even today, he's—I correspond with him at Christmas through Christmas cards, but that's about it. That's the way he handles everybody, just kind of hands off.

But I learned something from Neil: you can't be a national hero and do a job, a specific job. No way you can do it. As I said, I had adjoining offices, and Senators and Congressmen would come bring their constituents in there to get him to sign whatever it was. He could not do his job. He finally had to leave. He went to the University of Cincinnati [Ohio] to teach, same thing happened to him out there. They'd interrupt his class, people coming in. And so he went to farm out in Ohio, and I think that's what he's doing now. As I say, I don't have a whole lot of details, because he doesn't open up to anybody very much.

But I guess if you had to pick a guy to be the first man on the moon, and to know that he's never going to cause the country any problems—see, the astronauts were quite different, the ones I knew, the original astronauts. They were a fast-living, don't-think-anything-can-ever-happen-to-me kind of guys. "It's not a risk. As long as I do it, I'm going to come out okay." That was their feeling. The movie that was made about them is pretty representative of what they were. Neil was quite different, and [John H.] Glenn was quite different, too. They were the two astronauts that were quite different from the rest in that sense. They were very staid. And of course, Glenn had quite a career in the Senate, and the [NASA] Center's named for him now, rightly so. But Neil just kind of stayed to himself all this time. But, you know, you've got to give a guy like that credit. He's going to be a national hero forever. He is the first man on the moon.

JOHNSON: We've heard a lot of people describe the Langley Center, when it was under NACA in those early years, as a family. Because the community didn't know what to do with you—as you mentioned earlier, they weren't real sure about these people coming in, and a lot of the people, the employees, socialized together and that sort of thing. Did you find that true?

KILGORE: Well, as I said before, we were the Brain Busters. Matter of fact, the [NACA] people tended to find apartments in Hampton. In one area of Hampton, on Elizabeth Road. That's where I started out. We socialized together. We had the Green Cow Dances, that was the social events. Green Cow, C-O-W.

Now, how it got its name, nobody knew. It's just like Virginia Tech, that I went to, is a Hokie. Nobody knows why. Don't know where it came from. Green Cow, nobody knew where it came from as far as I know. Well, anyway, we socialized together. We had [dances and parties], this kind of thing. We lived together in communities, [which eventually] changed. I think Ann had a lot to do with changing that. When she got into politics and people got to recognize that, well, these people aren't all that different from the rest of us. Matter of fact, most of my good friends now are people who were born and raised in Hampton, and you know, their fathers were fishermen and all this, whatever they did in Hampton. That's what they did mostly, crabbing, fishing in the early days.

To some extent, the people were quite different, and you can understand why the locality didn't accept them. They were not only well-educated, they were above well-educated [and perhaps a little haughty]. I remember my next-door neighbor—he worked in the towing basin, the tank, to get data on sea-planes. Lloyd [J.] Fisher—Lloyd was quite a technical guy, and he was going to buy a carpet sweeper. Well, he went down to the stores, and they gave him the bill of goods about how this is better than that, so he came back and he says, "Look, the one thing you want on a carpet sweeper, you want high suction. The thing's got to have suction. That's it." So be borrowed a manometer out of the full-scale tunnel, and he went around to all these stores, so he hooked it up [and measured the sweepers suction]. Well, you could see how these people

would [roll their eyes and] get [a brain buster] impression. But on the other hand, after he left, everyone of them individually called him up and said, "How'd mine make out?"

JOHNSON: They could have used that as a statement.

KILGORE: That kind of represents the way people thought about it. They appreciated him after the fact, when they found out that they could be a part of the community doing some good.

JOHNSON: Your wife, obviously being in politics in a time that not that many women were doing that sort of thing—and there were some women at Langley but not very many, a lot of them were in those computer positions. Do you remember any of the early women engineers that came in, and how that was handled and how that worked out?

KILGORE: Yes. There was one mechanical engineer [named Kitty Joyner]—matter of fact, she worked for me afterwards. She was a very capable engineer, but in the early days, she wasn't given [an opportunity]. There was a lot of feeling that women shouldn't be engineers. That's probably the reason there weren't any more of them. But the woman who [made a tremendous contribution was] the head computer at Langley, [Pearl Young]. She probably did more for Langley in terms of making sure the reports—she took this data, and put it into a usable form, and the engineers would come to her and they'd have all this calculus and [math] gibberish, but she was a mathematician so she'd change all this into a very readable form. They got to depend on her. She was it. If she approved of a report, that was a good report.

JOHNSON: Let's talk about when you were offered a job and moved on to Headquarters. How did that come about, that position?

KILGORE: A fellow I knew from Ling-Temco-Vought, from the Scout Program was in Headquarters. He was in OART at the time, and he was there only temporarily. I didn't really know that. But he asked me to come up and be his deputy. I had worked with him before. I said, "Well, that'd be interesting." He said, "You know, you don't have to leave your family. You just come up and work for a year, or six months, or whatever." It turned out I [essentially] worked the rest of my career [at NASA Headquarters], and I commuted the whole time. I'd leave Friday afternoon, and then I'd come back Sunday night, and spend the whole week in Headquarters. I did that for several years. That's a struggle, too, I'll tell you. But it was an interesting place to work.

You cannot change NASA or NACA from a Center. You can change that Center, can do a lot of things, but if you've got different Centers and different organization, the only place you can make a change is from Headquarters, because [they are] the only people who have the responsibility for more than one Center at a time. That's the reason Roy Jackson and I were able to start that Aeronautics Program and change the Aeronautics Program for all the Centers. We had the responsibility to do that at that time. Oran [W.] Nicks, shortly after, came to Langley to work and became the Deputy Director here at Langley. He was just on a temporary assignment in Headquarters. I was in charge of OART until they brought Roy Jackson in from Northrop, and then I was his deputy. Then when he left, I was made the Acting Administrator for a couple years. Then I organized Management Operations, which [was] responsible for all the Centers. I

was given the job of organizing that [by the NASA Administrator] and spent [most of] the rest of my career [in that organization].

JOHNSON: Talk about some of the things that you did in those positions. I know that one of the things that I heard was that you designed a performance rating system for NASA?

KILGORE: Yes. The Congress voted, and it was suggested by the Civil Service Commission, that we have a Senior Executive Service [SES]. And theoretically, this was the people who were the managers in NASA at a level of, say, Deputy Center Director up. Well, in some cases, Division Directors at Centers would be Senior Executive Service. It was up to the agencies themselves to design a system for rating the people and deciding who went into the Senior Executive Service. In my job as Associate Administrative Management Ops, I inherited the job of doing all that, so I pulled together a group and designed the appraisal system.

My problem with appraisals prior had been that sometimes it gets misused, because people go about it in the wrong way. They come out with the wrong answer. They've got ten questions down here, and you answer those questions, and depending on how people answer those questions, I get a higher rating than you do, see? Well, that may not be right at all. You may be twice as good as I am. So you needed some leeway at the top in rating people, in using your judgment as to the job that they're performing. You need a system by which the people themselves can set what their goals are going to be, along with you reviewing them afterwards and agreeing that that's a good goal. Then at the end of the time you see, "How did you do on those goals? How many of those did you carry out? How successful were you in your job?"

The second part of the Senior Executive Service that I saw as necessary was this role of the manager. That the people were managers. and that's the toughest one to handle, because you've got some very, very bright, individual workers in NACA and NASA. NACA was full of them. NASA has less of them, because it's more a business-like organization with contractors and all that. But you needed some system that determined who were the managers and who were the individual workers, and you can't ignore the individual workers. You've got to have a route for them to come up, money-wise, to a higher level.

Those you have in the Senior Executive Service, the ones who are going to manage organizations, you had to make sure, first of all, that they wanted to manage. They wanted to do things through other people. They weren't going to be individual managers and [try to] do it all themselves. I'll never forget sitting in on a conference over at Wallops in which the Director at Wallops [remarked about a young man] in the other room being interviewed. He said, "Watch this guy." He said, "He's going to be Director of Wallops one of these days."

So the interviewer asked him, "What did you enjoy doing?"

"Well, I built this, I built that."

He said, "How did you do that? Did you have people helping you?"

"Oh no, I did it all myself." Everything he did, he did all by himself. Well, you could just see this guy, very bright guy, getting to be the Director of an organization like Wallops and being an individual worker. He had no interest in managing people or bringing people along, training people, the kind of things you need to do. So that was what I strove to do [with the system; make sure people had both the interest and ability to manage.].

I don't know what the appraisal system looks like today. It probably doesn't look anything like that. But that was my objective at the time, and it worked pretty good for the years

that I was there, I thought. I think we had a pretty fair system of rating people and making sure that people who came into the Senior Executive Service were truly managers and not individual workers. Also, as I said, making sure [at the same time] that the individual workers got their due in money and [prestige]. But just keep the two systems separate. Using those thoughts, we were able to pick out the people that—as far as I know, it's still being used—that Center Directors would be SES level something of other, Associate Administrators would be at level so and so.

Then of course you've got the political appointees, which you don't have anything to do with. White House handles that. But NASA was very lucky in that respect. When I was there, the Administrator, the Deputy Administrator, and the Chief [Council] were the only political appointees we had. Now, when [President James E.] Carter came in, he had some people who wanted more influence in NASA. So he sent a [few] people over, and we were required to place them. And we did place them in jobs, but they were innocuous kind of jobs, and after a while, they became dissatisfied and left. So we ended up with those three people again, [as our only political appointees].

JOHNSON: During your career, and you were talking about the SES System and being able to be a good manager, who would you say you patterned your management style after? You started managing pretty early on in your career.

KILGORE: [Several] people had a great influence on me. [One was Floyd Thompson. He could hear many varied recommendations, sort them out and in concise terms lay out a simple plan of action. Another] was Webb. Webb had a management style of not only making sure he knew the people involved—and knew them as personally as he could get to know them. Secondly, he

managed by options. Now, what I mean by options—I know as a kid I was reading a story about a train. The engineer on this train thought one day, "What would I do if I met another train on that track?" He says, "Well, I know exactly what I would do." It happened to him [when] there were a bunch of boxcars on [the track ahead. He had previously decided to] just keep going; otherwise, he would have derailed and killed a lot of people. He just plowed through all these [cars with no major damage].

I learned the object lesson from that, that if you have thought [ahead] about the things that can happen on a project or on an organization that you've got, and you've got a solution to that in your head, that's managing by options. That's what Webb did. Webb thought about everything. "What happens if the Congress doesn't give money for this?" Or, "What happens if we get—" He had already considered that, and he had an answer to it in the back of his mind, and that I learned from him, and that kind of set my management style as much as anything.

The other guy was Roy Jackson, from Northrop, who was brought in as Head of OART, which Langley came under at the time. He only had two years to shape that organization up. The organization had become very ingrained. They only thought about their little organization, their little bailiwick in Headquarters. I got there about six months ahead of him, so I met with him, and we discussed it. He knew exactly what he had to do. He came in, we reorganized the whole place. We got some new talent in, got some people in from the centers and revamped the whole thing, [including more relevant research].

But the other thing that Roy had to do [because he had a limited time], he had to be the general. Now, that's not my management style, and it never will be. But there are times when you have to employ that. If you only got two years to do something, to shape something up, or a limited time, you've got to be the general. That's why, in the military, generals are generals:

because they only have a limited time to shape up things. "You'll do it this way. My way. I'm not going to discuss it with you. My way." That's the general speaking.

Well, Roy was the general, and I knew what he was doing, [in the near term to promote rapid change]. But my [long range] management style [was] quite different in that I believe in trying to build a lasting organization, because I intended to stay with it for a long time. And that was my style. That and managing by options, I think. Of course, a concern for the people. That's a part of that building a lasting organization. Making sure the people are trained properly.

I found out one other thing: that if you could put a person in a job in which they are interested, they're [generally] going to be a success. If they're not interested, they'll play lip service to it and [find other outlets for their talents]. I know a lot of people at Langley who, in the early days, went outside Langley [to fulfill their interests]. They went into the Church, or they went into Boy Scouts, and they were happy because they were doing something that they liked to do. One fellow's sole interest in life was in making money [and his job included supervising the cafeteria]. Well, of course, you can't [get rich] working for Langley, or in the government. But that was his motivation. When he played poker, he wanted to make money. Everything was money. That was his sole motivation. When he inherited the cafeteria, the cafeteria was in kind of the doldrums, and it certainly didn't make money. It lost money. He says, "Ed, this thing's going to [change]."

They had a problem with the inspectors. The inspectors would come over, you know, and they [would find] dirty this and dirty that. First thing he did, he said, "Every person in here is going to get a crisp five dollar bill every month if you get a good inspection. If any one person gets a bad [report], nobody gets money." They never had any problems from then on. That was the cleanest place you'd ever seen. But it illustrates my point. He made a profit out of that place

within six months by just running it properly, because that was a job that, in his mind, he liked to do. He liked to make money out of things. Well, you can't always find a job to fit people like that. But if you can, you're just lucky, because they're going to be a success at it.

JOHNSON: It sounds like it. You stayed with NASA until 1981, is that correct?

KILGORE: Yes.

JOHNSON: And then you retired. What did you do after that? Did you continue to consult?

KILGORE: Yes. I did quite a bit of consulting. [However, I did more than I wanted.] I really wanted to retire. I have a lot of interests. I have my art, I have my woodworking, I have my tennis. I like to read. I like to do all these other things—and I was offered a lot of jobs, and everybody is, when you go from Associate Administrator, the industry [is interested]. They want you for your name more than anything else, not what you know. But anyway, I decided, "I'm not going that route. I'm not going to take a job." So I didn't. But the Academy of Public Administration came to me and said, "What do you think is the major thing, if you could improve it, in the Federal Government?" I said, "Bureaucracy. It's easy. Bureaucracy's going to hang the Federal Government," and we see more evidence of it every day. The Congress is gridlocked and everything's gridlocked, and [no one knows] how you get out of it.

Well, they took that on as a challenge, they got their people working on how do you get rid of bureaucracy in agencies, and I think it made some impact [in reduced paperwork], but not big. Because bureaucracy [has a firm grip]. It's there, and it's going to stay. The only way to

cure bureaucracy [may be] to start over. I remember at Langley. In my early days, we were in a big old warehouse building. Later we moved into over on the west side, into an old barracks kind of building—most productive organization I ever had. Nobody had air-conditioning, nobody had a fancy desk. Then we got a brand new building later on, and everybody had a [new] desk, you had air-conditioning, and productivity wasn't near what it was with that [original] group. So something about people kind of sharing their misery by putting it into the productivity. I don't know if that's a good thing to do. You may have noticed that yourself, that the better the surroundings get, the more people tend to socialize, the more they tend to not be productive.

JOHNSON: The atmosphere during those early years, too, was more of a can-do, everybody—people were more willing to take chances.

KILGORE: Yes. No bureaucracy, as I was starting with. Everything's done with a handshake or a telephone call. If somebody said they were going to do something for you in a telephone call, you can hang up and be pretty sure that was going to be done. If it went to Headquarters, you make a telephone call, and unless you wrote ten memos, you'd be pretty darn sure it wasn't going to be done. It's just a difference in a bureaucratic organization and a non-bureaucratic. But in either case, you've got to learn to live with whatever it is.

JOHNSON: You mentioned earlier, too, while you were at Headquarters, you were able to dispel some of that feeling that you were talking about at Langley at that time—more of a Center-

focused and being more territorial. You were able to make some changes when you got to Headquarters. How did you do that?

KILGORE: I did it as much through the Senior Executive Service as anything else. I had a real stick to wave over people, and if they weren't doing the management job and coordinating with the other Centers' programs—split the programs up so that both of them have a share in the program. Matter of fact, Viking—Lewis [Research Center] had a big part in Viking. And when it started out, they didn't much want to deal with Langley, even though Langley was the [lead Center] in this program. A fellow named Jim [James S.] Martin [Jr.] was the Project Manager [at Langley and it didn't] take very long to push them back into [the team] under the Senior Executive Service, you could replace people.

That's a pretty big stick, so you shape these people up by telling them, "Look, you either shape up or you find something else to do." Pretty soon, that gets to be a way of life. I don't know how it is now, I can't tell you, among the Centers. I suspect there may be more competition now than there used to be because there's a limited budget, there's a limited program. And as to what Centers get, I'm sure they're battling like heck to get their share of whatever there is.

In Langley, there's a lot of working to stay alive because the aeronautics program—like I said, mainly because of the fact that Boeing and these other companies aren't coming in here to test. They've got their own wind tunnels nowadays, so Langley's going to have to fall back, which I'm sure they have, on basic research. And hopefully they do the right basic research to get to be a player in the aeronautics industry. Hopefully some of the space activities they're doing will also fit in with the new Administrator's long-range plan, [which is probably] going to

change if we get a new administration. [Every new administration has a new plan which they never fully fund.]

JOHNSON: That's right. Just have to wait and see.

KILGORE: Yes. I was just lucky to start out in its infancy, when we really had a blank check to do something. To go to the Moon. That will never happen again. Everybody since then, every President, said, "Well, we're going to give them another blank check. Go to Mars." That gets about that far, and then the money gets cut off. That's it.

JOHNSON: Looking back over your entire career with the NACA, and then again with NASA, is there anything that stands out in your mind as the most challenging time of your career?

KILGORE: I think the most challenging time was when I was [Acting] Associate Administrator of the [NASA] research organization, OAST, and Associate Administrator [for Management for NASA]. The headquarters time. That was the most challenging. Every 15 minutes of the day was scheduled. I mean, it was a high-stress; [however], I'm not a high-stress person. I didn't let it bother me, but that's just the way the jobs at that level are [by design].

JOHNSON: Is there anything that stands out in your mind of maybe a project or something that you worked on that you're most proud of?

KILGORE: I can think of a lot of them that I enjoyed. I'm not sure about one that I'm most proud of. The Scout, I loved that. I loved Echo. The system for evaluating people for NASA. The system I set up for training people—we've got a school at Wallops that trained people, I set that up.

JOHNSON: What was that? What type of school did you set up at Wallops?

KILGORE: It's a management school. We have a lot of very bright young people. If we can single out those young people at an early age—now, we may have made some mistakes—but go ahead, single out those people at an early age, and challenge them by giving them something to do, and put them through management courses, and put them through courses where they understand NASA and they totally understand the Centers and the organization and all this. That's what the school at Wallops that I set up does. [There were] about three sessions a year—each Center was allowed to send a couple people, a couple young ["comers"], to it. These supposedly were people who were young comers, you know? They were going to be the next generation management. A lot of them, I'm glad to see, are now in the management chain and making the decisions.

But that was the idea behind it. I can't tell you how it stands right now. I made it a point to go talk to each class for about ten years, [and challenge them to accept management responsibility], I've just kind of dropped out because I'm not very [close] to NASA these days. Not because I wouldn't like to be, it's just that I've been out of the business too long. The new Administrator [Michael D. Griffin]—I've had lunch with him a couple times—he's not only a very bright guy, I think he's got his head screwed on right. We'll have another administrator, I

guess, if the politics go the way they look like they're going now. That's a shame, because this guy was really doing some good things with NASA.

JOHNSON: Yes, he's done a lot.

KILGORE: The only thing he's not doing good, and he has no control over it, is the budget. If they just give him a couple million more dollars, instead of putting it into social programs, you think of all the things they could do. When I was the Associate Administrator, the Administrator asked me, "Is there any way to quantify in terms of dollars what NASA technology has meant to the gross national product at that time?" I said, "Well, let me get some economic experts and see." So I went out and talked to a few of them, and finally I hired a group to look at it. They took [past] projects and tried to follow the projects through to see what kind of an impact they had in terms of becoming products that could be sold, or have an influence on industry. [Like all economics, it's a somewhat] inexact science.

But what they came out with was that for every dollar that was put into technology for NASA, there was a nine-dollar return to the gross national product. Even if that's off by a factor of two, you could buy into that almost any day. The report still exists someplace of what all this is based on. I think it's probably pretty accurate. If you really believe that, if the Congress and the President believed that, they'd put several more dollars into NASA, because the return on the investment in technology alone—I don't care what you say, "We're going to the moon, we're going here," you need projects like that in order to foster technology.

There's two ways you can foster technology. One is to have a war. That's a terrible way. Technology really [accelerates] up during wars. The other way is through some kind of a

[major] scientific endeavor. [NASA has even played a small role in aiding health systems, like the diabetes implant.] It gives [diabetics] a shot of insulin on the right schedule. [A doctor] at Johns Hopkins [Baltimore, Maryland] came over and we worked with him in terms of batteries and miniaturizing [the hardware]. So we've had an impact on the health system to some extent. Instead of into social programs, you need to put—maybe you've got to do that too—but you need to put money into something that's going to develop technology [and increase the gross domestic product]. That's what NASA is set up to do [if given the opportunity].

JOHNSON: If you don't mind, I'm going to ask Rebecca if she has any questions that we haven't covered that she may have thought of.

WRIGHT: I wanted to ask you about your involvement with the [Virgina] Air and Space [Center].

KILGORE: When it was formed, I was on the committee that solicited funds for it. The day it opened—they had an organization and I was made President of it. We had the Governor and all the dignitaries down, and I took them through and showed them the place. I was President of it for about five or six years. It was tough going in those days, because any time you start a new museum, it's going to take several years for the people to discover it and to get the habit of going back. [But that] finally happened. Now it's making money. But we almost didn't have enough money to pay the help there for a number of times, we were about to go bankrupt. We had a stopgap, the city [of Hampton] would have had to subsidize us, but they never did. It all turned out all right financially, we were okay. I'm still on the Board, I'm Emeritus. I go down and see

what they're doing every now and then. But that's one of the things I'm very proud of in this city, that Air and Space Center.

WRIGHT: The only other question I had is when we arrived, you mentioned that you and Chris Kraft of course went to school together, and then you worked on a project together at Langley. Did you have an opportunity to work with him closely through those next years, especially after he left?

KILGORE: Oh yes, very close. When I was the Associate Administrator, all of the Centers reported to me, so I had a lot of meetings with Chris and all the other Center Directors. Matter of fact, we had Center Director meetings a couple times a year, where they all came to Headquarters and we all got together. They didn't like them, but [we needed to bring the agency closer together by sharing ideas].

WRIGHT: You got to see old friends and classmates?

KILGORE: That's right, yeah. As I said, Bob Thompson was the head of the Space Shuttle. Have you met Bob?

WRIGHT: Yes, we have.

JOHNSON: He still plays golf. Can't get him to play tennis anymore.

WRIGHT: Well, that's all I have. Thank you.

JOHNSON: This has been very helpful. Is there anything else that we haven't talked about that you wanted to mention?

KILGORE: Well, there are probably a lot of things, but I can't think of them now.

JOHNSON: We appreciate you taking your time out and talking to us.

KILGORE: Well, thank you.

Read more about Edwin Kilgore's history
Space and Aeronautics Technology - Past and Present
by Edwin C. Kilgore

SPACE & AERONAUTICS TECHNOLOGY
- PAST & PRESENT-
BY EDWIN C. KILGORE
Former NACA and NASA Executive
2000

As an English Poet once said, "He who builds under the stars, builds too low". The space program carries on the American tradition of exploring – of expanding our knowledge and horizons.

In looking back, it is a great time to have lived – all the major inventions, with the exception of the printing press and the steam engine, have taken place in my lifetime. In 1939, the NACA (predecessor to NASA) Chief of Research testified before Congress that the law of diminishing returns had been reached in aeronautics and all important research had been accomplished. History has shown the absurdity of his prediction. Technology is in its infancy and still growing asymptotically. We tend to always underestimate the technical future but I think you will agree that Engineers and Scientists will be center stage.

It was a great time to have had a career. I've had a chance to work with the aviation pioneers Hunsaker, Dolittle, Thompson, Dryden, and to be a peer with those who will eventually be referred to as space pioneers – Armstrong, Gilruth, Kraft. Neil Armstrong and I had adjoining offices for almost a year. Neil was a technically competent aeronautical engineer but it was difficult for him to do any job in Washington. He was constantly requested by legislators for appearances and photo sessions. If you ever have a chance to be a national hero, turn it down – it's an impossible job. I never discussed the lunar mission with Neil. He was besieged with insane questions. However, on one occasion, he volunteered that looking back at the earth was much more spectacular than the moon itself. Looking at that beautifully colorful marble in space had

a profound effect on Neil and other astronauts. The realization that this fragile ball, with its tenuous atmosphere, was man's responsibility to destroy or preserve. When we talked, many times, Neil would prop his feet on my desk. I confided in him that I couldn't look at his foot without seeing his footprint on the moon. He laughed but when he left Washington he gave me a large signed picture of that famous lunar footprint which I still proudly display in my den.

Aviation has come full cycle in one generation, from the airplane to the spacecraft to the first hypersonic aircraft-the shuttle-and with a one stage to orbit spacecraft now approaching reality. One of the primary reasons for the rapid technical advances lies with the improvement in sensors. We have progressed from crude low response sensors such as the early undamped manometer tubes for airfoil pressure distributions and visually observed tufts to exotic strain & pressure sensor and laser velocimeters which yield many orders of magnitude more data per unit of time than before. However, one of our best and sometimes most reliable sensors still is human observation. The argument still exists between manned and unmanned spacecraft for space exploration with worthy advocates and arguments for both. The space exploration picture would not be complete without both. I recall one graphic example of effective use of the human sensor in research. It involves Dick Whitcomb, an aeronautical engineer at NACA and later NASA Langley Research Center. Dick made several significant aeronautical discoveries such as the area rule, the supercritical wing, and winglets. Dick wasn't a highly theoretical researcher but he was born with the innate ability to understand how air flows around objects. He would file a little here and a little there on wind tunnel models, reducing drag with each stroke of the file. The contributions of his area rule made it possible for fighter aircraft of the day to meet drag specifications, saving the nation billions in redesign costs.

To discuss space history, it is important to review the environment that existed at the time. In the late 40's and early 50's, several groups in the U.S. were doing some space related research. Von Braun and his Penimunde Group, working with the Army, carried on a small effort in rocket research. JPL researched solid rocket propulsion. Jack Townsend, of NRL, headed the development of the Vanguard orbital rocket and NACA

launched multistage sounding rockets, at Wallop's Island. Max Faget of NACA started his career as the conceptual designer of the nation's manned spacecraft with sketches of the "Hy Ride" which later became Project Mercury.

All this effort, at best, was fragmented with little dedicated funding. Space Research went from the back burner to the front burner in 1957 with the successful Sputnik launched by the Soviets. Sputnik came as a shock to our technical superiority. Our national prestige took another blow when the first Vanguard collapsed on the pad. It wasn't until a year later that Von Braun was able, with crash effort, to launch Explorer I, into orbit carrying Van Allen's spacecraft to measure the earth's radiation belts. Concern in 1957 by the Congress and President Eisenhower led to formation of NASA to reestablish our national prestige. Eisenhower and Senator Lyndon Johnson were convinced the new space program should be separated from the military to avoid escalating cold-war tensions. James Killian, Eisenhower's science advisor, is given credit for pulling together the organizations (NACA, JPL, Redstone, and NRL) which became NASA. All these had outstanding characteristics in common:

- They all had committed outstanding scientists and engineers. Bob Gilruth once told me the story regarding his employment into NACA. Five thousand engineers took the exam for Junior Engineer. Gilruth was the one selected – a highly selective process to say the least.

- They were all in-house organizations where hands-on experience and individual technical excellence was the norm..

- They all stressed individual responsibility for problem solving through personal attention to detail without having to rely on inspectors and quality controllers.

It was a judicious selection of the parts which made NASA an organization well suited for its task. Homer Newell of NRL brought the nucleus of a space-science program. Jack James of JPL brought the management expertise for complex science

projects. Von Braun brought his mission vision and expertise for large liquid rockets. Hugh Dryden and NACA brought probably the most productive federal research organization in existence. The National Advisory Committee for Aeronautics (NACA) was formed in 1915. Professor Jerome Hunsaker, of MIT, had visited Europe earlier and reported that the U.S. was woefully behind in aeronautics. The Russians, British, and Germans all had over 1,000 aircraft while the U.S. had less than 30. President Wilson signed a Navy appropriations bill which included a rider establishing an aeronautical research laboratory "within overnight boat or train from, Washington, DC." Langley Field in Hampton, VA met this criteria and the first NACA laboratory was formed there. We all know that management by committee is ineffective; however, the NACA was run by a Committee both effectively and well. Men like Dolittle, Hunsaker, and Orville Wright comprised the Committee which met periodically, made recommendations as to new research problems and reviewed progress on existing work. The Committee understood its job of guiding research and assuring progress in an environment favorable to innovation and as free from bureaucracy as possible. The NACA and its four laboratories and 8,000 people became the largest segment of the newly formed NASA in 1958. It was a busy time for NASA. Project Mercury was started by the Space Task Group under Bob Gilruth at Langley. New booster systems were started including Centaur and Saturn. However, of the 37 satellite launches attempted by NASA less than 1/3 reached orbit. NASA got its start in the communications satellite game with the successful launch of Echo, a 100 ft. diameter mylar balloon, intended as a passive reflector of radio signals. Active communication satellites later proved to be much more reliable than some envisioned, negating the need for passive reflectors. Echo's biggest impact was that it was visible to the whole world, boosting the U.S. national prestige. Echo was an interesting development job. Acres of ½ mil. aluminized mylar had to be folded and packed in a 27 inch diameter spherical container. The first attempt resulted in filling a small room in place of a small sphere. The key came when I observed my wife take out her rain hat (folded in a neat strip) and unfolded it to a perfect hemisphere. We made scaled up fold patterns based the rain hat and successfully folded Echo.

Jerome Wiesner, science advisor to Kennedy, chaired a committee critical of the Space Program and questioned its cost & future. Conveniently, the Soviets came to the rescue with the orbital flight of Yuri Gargarin in 1961. The fact that Shepard flew his Mercury capsule on a 15 minute suborbital flight a month later did little more than prove we still lagged in the race. Both Congress and Kennedy were concerned and looking for solutions. Jim Webb, the new Administrator of NASA, provided an aggressive 15 year plan including a guaranteed way to win the space race by leapfrogging the Soviets with a manned lunar landing. Webb was one of the super-managers who thought in options; therefore there were few surprises even in gigantic undertakings such as Apollo. He had previously been the head of the Bureau of the Budget and knew all the important decision makers in Washington by first name. He was certainly the right man for the time. At a NASA-alumni meeting recently, Webb said he told Kennedy he would undertake the moon landing if Kennedy would accompany him to personally talk to the Congressional leaders and get their blessing for the project. As he related it "The President and I received 100% agreement on the Hill." Webb also said that later his staff presented him with a cost estimate for Apollo. He doubled it on the spot, and after thinking about it overnight, he doubled it again. It turned out to be about right. Let me remark for those of us who have big engineering egos, that Webb, who had no scientific degree, had more impact on the space program than any other one person.

Webb was pleased with the blank check he now held to proceed with the lunar project. Gilruth, obviously, was somewhat shocked since he was still in the midst of Project Mercury problems. However the NASA technical team accepted the additional challenge and proceeded to sort out problems and look at solutions. First, we knew little of the detail of the moon. Geologist, such as Shoemaker, predicted up to 50 ft. of dust on the surface. Gold predicted surface dust so fine that landing would be hazardous. We referred to this as "Gold Dust." It was interesting that the geologists interpreted the first high resolution lunar photographs as supportive of their individual predictions. Ranger and Surveyor, being developed at JPL to provide lunar photos and scientific data, were reoriented to answer some of the lunar surface questions and to aid in selecting an Apollo landing site. The Ranger experienced five straight failures. Jack James, of JPL who took

over the project management, recognized that the many spacecraft systems were sound but the interfaces were faulty. He reorganized the management team into a cohesive project group with all systems represented on a full time basis. The last three Rangers were successful. This was the first recognition of the necessity for a full-time project office with meticulous attention to detail (including the interfaces) and it set the precedent for all future NASA Science projects.

The first Surveyor came within a few seconds of its soft landing on the moon and all communication was lost. I was a part of the failure investigation team and we were baffled by the unique circumstances. We finally subscribed the failure to a burn-through and explosion of the surveyor retro rocket motor which had experienced similar development problems. However the telemeter record had stopped abruptly, which was uncharacteristic of an explosion, and called for a double failure. In any case the rocket motor nozzle was "beefed up" on succeeding Surveyors and all soft landed successfully and provided photographic proof that the lunar surface would support the manned landing.

It was recognized that in addition to the Ranger and Surveyor data, selection of a lunar landing site required high resolution mapping of the moon. The Lunar Orbiter provided a high resolution map of about 90% of the moon-even of the lunar backside which was previously unobserved by man. The Lunar Orbiter made photographs from lunar orbit on film using image motion compensation to allow for the high forward velocity of the spacecraft. The film was later scanned and the digitized data returned to earth and reconstructed, thus providing many times the data that would have resulted from real-time video transmission as was done with Ranger and Surveyor.

In 1959, George Low, head of manned space flight office of NASA, had the foresight to initiate a series of studies aimed at solving the many problems associated with a manned lunar mission. These studies helped to prioritize the key Apollo hardware developments. Guidance and Control was given top priority. To hit a small target in space where both the launch site and landing site moved relative to each other was recognized

as a complex task. The contract for the Guidance and Control system was the first major Apollo contract and was given to the Stark Draper Laboratory at MIT. Major advances by the Draper Laboratory in gyros and computer systems led to a successful Guidance and Control system.

The development of the F-1 engine for the Saturn V launch vehicle was undertaken by Wernher Von Braun and his team.

Many equally complex problems such as re-entry, power systems, radiation protection, and weightlessness were tackled and solved.

The mission mode was very controversial with direct landing and earth rendezvous preferred. However, John Houbolt, of Langley, persistently pushed the lunar rendezvous mode which was finally accepted as the mission mode. Von Braun wasn't entirely pleased with the decision because even though it was more efficient, it precluded the development of a gigantic Nova launch vehicle which he envisioned as needed for future manned planetary missions.

It was now clear that rendezvous and docking in space had to be mastered in order to complete the Apollo mission. A hurry-up scale up of the Mercury capsule was named Gemini and provided invaluable information on man's ability to work in space, to withstand prolonged weightlessness and to rendezvous and dock. The advances in fuel cells, control systems, navigation, space suits, and the melding of a large NASA—contractor operational team made the Apollo problems much easier to solve using the Gemini experience.

All went well until a fire in Apollo command module during pre-flight tests killed 3 astronauts. Webb reflected the country's shock while reminding of the risk of space flight. He expressed amazement that the "first tragedy would be on the ground." Unlike the Challenger accident, NASA appointed an accident investigation team the next day headed by Floyd Thompson, senior NASA Engineer and head of the Langley Research

Center. A through review of all spacecraft internal systems, and materials was made. George Low took over as Project Manager and deserves much of the credit for making the changes which made the spacecraft much better, safer, and ultimately successful.

Later I was a part of the Apollo 13 investigation team. You will recall that the oxygen tank exploded during flight. Fortunately the tank failed outward, away from the astronauts or we would have had the first catastrophe in space. Use of the oxygen from the lunar lander, attached to the command module, allowed the astronauts to safely return to Earth. The culprit was small thermal switch, which could be purchased commercially for a few dollars. It was too small and welded shut, pumping more and more heat into the tank which eventually exploded. We, the investigating team, might have eventually found the specific problem but I cannot be sure. The project team, headed by Rocco Patrone, understood the hardware in great detail and succeeded in mocking up the hardware, reproducing the explosion and pinpointing the faulty thermal switch in a few weeks. I believe that the resistance to aid from the NASA project personnel after the Challenger accident for fear of a cover-up, was a mistake. I submit that an in-house NASA investigation could have pinpointed the management and technical problems with much less time and cost and had the Shuttle flying safely again years earlier.

The Challenger and Hubble telescope are prime examples of lack of attention to detail. Neither of these were high tech problems. "O" rings have been used for years. A knowledgeable engineer would have recognized the faulty "O" ring design in the Challenger solid rocket motor. In the case of the telescope, spherical aberration is not a new or high tech problem. Lack of attention to detail by knowledgeable people cannot be replaced by after the fact inspectors or accident investigators.

Early in NASA's History there were arguments in NASA and even in Congress between manned and unmanned programs. It was clear that Apollo would demand a large share of NASA's budget. It was also clear that the preponderance of Congress wanted emphasis on manned programs because of international prestige.

Webb somewhat defused the criticism of Apollo by designing and selling to Congress a broad program of Space and Earth sciences and meteorological and communication satellites to go along with the manned program. The manned versus unmanned controversy still exists today. Manned advocates contend that to stop manned exploration would be as inane as sending robots to explore the Western U.S.A. originally.

The first weather satellite (Tiros I) was launched in 1960. A vidicon camera sent photos of cloud cover back to Earth in digital form where it was reconstructed. Since 1965, weather satellites have tracked every dangerous tropical storm. Weather forecasting has been greatly enhanced by the capability of "met" satellite program.

Probably the most notable commercial success from space is communication satellites. Starting with the launch of the Early Bird satellite in 1965, world-wide voice and video are now the norm. The idea of a communications satellite at synchronous altitude was advanced by Hughes Aircraft which led to the launch of the Syncom Satellite. Synchronous satellites became the basis for the world wide communications system which we enjoy today. The Comsat Corporation was set up by the Congress with 114,000 stock holders and became an outstanding financial success.

Planetary exploration started with Mariner IV fly by of Mars, providing the first close up views of the planet. Later landing on the Martian surface by two Viking Spacecraft provided a whole new insight into our planetary neighbor. However, sophisticated sensors failed to detect any life forms. Viking represented a technical achievement close to that of Apollo. The Mars mission was originally proposed for a Saturn V launch vehicle; however when the estimated mission cost became prohibitive, a much smaller spacecraft was designed for launch on a Centauer. Through a quantum state-the-art advance in microminiaturization of electronic components, Viking contained all the data gathering capability of the much larger Saturn V spacecraft. Design of a tripod legged lander versus an omni-directional lander represented risk of the space craft "stubbing its toe" on a large rock on landing. Subsequent photos of the rock-strewn landing site showed that the cause for concern was real. The gamble paid off with both

spacecraft landing safely. The tripod design allowed for much more instrumentation within the overall weight allowances.

The planetary exploration program provided detailed insight into our planetary system. Voyager gave us spectacular pictures of Jupiter, Saturn and Uranus. Two JPL scientists (Reed and Solomon) originated a software "error –correction-code" which they convinced the Project Manager to include on Voyager. Like all good Project Managers, he was reluctant to employ the new software; however, he agreed when the first Voyager photos appeared quite fuzzy. The use of the Reed-Solomon software immediately made a remarkable difference in picture quality. Today a 15 billion dollar industry has grown up in the U.S. using the Reed-Solomon digital data recording techniques. The Japanese have used the basic idea for over 65 additional patents.

I recently headed a study which attempted to quantify the effect of NASA technology on the United States GNP. Economist at the Midwest Research Institute using a method devised by Dr. Solo concluded that for every dollar spent by NASA there has been a $9.00 return. The fact the Dr. Solo won the Nobel Prize for his method lends credibility; however, even if the answer is only half right, it is still an attractive return on the national investment.

In conclusion, it has not only been a spectacular and astounding three decades in terms of aeronautics technology and space exploration, but it has also been extremely profitable to the country. The space program has served as a forcing function for technology. Advances in communications, guidance and navigation, and computers, have resulted. It has given us the ability to better understand our own Earth and its complex systems while there is still time to have a positive effect on our environment.

We must continue mankind's exploration and search for knowledge to remain a viable people. "To quote from the Bible" "Where there is no vision, the people perish."