ORAL HISTORY TRANSCRIPT

WARREN J. NORTH
INTERVIEWED BY SUMMER CHICK BERGEN
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BERGEN: This is an interview with Warren North on September 30, 1998, at the offices of the Signal Corporation in Houston, Texas. The interviewer is Summer Chick Bergen, assisted by Carol Butler and Paul Rollins.

We're so glad you could be here with us. Let's start with your experience in the Air Force, or what was the Army at that time, during World War II. Did you enlist in the Army or were you drafted?

NORTH: I started college back in 1940, at the University of Illinois, and enlisted in the ROTC [Reserve Officer Training Corps] Engineer Corps at that time. I was in the Mechanical Engineering Department. After three years in the ROTC, they decided that since the war was on, we needed to be pulled out before we were commissioned, so we were [given the rank of] three-stripe sergeants and sent to the engineer officers' training school, which involved three months at Fort Leonard Wood, Missouri, for basic training, and then on to OCS [Officer Candidate School] at Fort Belvoir.

We were at Fort Leonard Wood, Missouri, building [pontoon] bridges in the swamps. We went by the orderly room one day and … found a notice on the bulletin board that said "Anyone who would like to transfer into another branch can at this point." This … was an edict from Washington. "You can transfer into the [Army] Air Force [or Field Artillery] if you like, but you can't transfer so-called downward into the infantry." It was their pecking order, apparently, in how you can transfer based on your technical background. So a good percentage of us from ROTC at University of Illinois transferred into the [Army] Air Force, pilot training.

I got my commission in [November] 1944, in Victoria, Texas, as a fighter pilot. At that time the war in Europe had just completed, and the pilots from Europe were being transferred into the Pacific, so they didn't need us right at that point to go into fighter operations. … They said, "We'll pick 10 percent of you to be instructors, and the rest can be divided among [towing gunnery] targets," and things like this.

… I wound up at Randolph Field, going through [AT-6] instructor school, then spent six months in Waco, Texas, training basic pilots who at that time were transitioning … from the Stearman into the AT-6, which was the advanced trainer when I went through training. So we trained the first group of cadets in AT-6 coming out of the Stearman, which was quite a jump for them. A lot of ground loops and a lot of [broken] axles, but they made it in fairly good shape.

…Then after six months of [instructing], they said, "Well, we don't need any fighter pilots overseas, but we need bomber pilots, so we'll pick some of you for bomber pilots." …I got [assigned] to B-17 training and then B-29 training, which I did, and wound up picking up a [full] crew in Lincoln, Nebraska, [for] the B-29, and then took that crew up to Mountain Home, Idaho, for phasing, for about two weeks before [going] to the Pacific.

It was during that two-week period that … the atomic bomb [was dropped], and we were all told that we could cease and desist and separate from the Air Force, which I did, and went back to college. This time I went … to Purdue [University], rather than Illinois, because [Purdue] had an Aeronautical Engineering Department which I wanted to specialize in. … I lost six months by transferring from mechanical [engineering] to aero[nautical engineering], but then got a degree in 1947 in aeroengineering from Purdue.

I interviewed with several companies [including] McDonnell [and] NACA [National Advisory Committee for Aeronautics] at that time—and went [with NACA] because it appeared a lot of research was being done that was very parallel to what I'd been trained in, in the propulsion option of jet aeronautical engineering. So I went [to] the Lewis [Research]

Laboratory, which was the [NACA] Propulsion Center at that time, and still is, worked under Abe Silverstein for several years. That was in 1947, I … [worked] for about a year in the altitude wind-tunnel testing the jet engines, including the engine that's currently in the T-38 at Ellington Field. That tells you how old that engine is. [Laughter]

After a year there, one of the pilots from flight research, Howard Lilly, had transferred to Edwards, which left a vacancy in flight, so I transferred over there and began flying with NACA as a research engineering test pilot, and flew everything that they had, all the World War II fighters and bombers. We had the F-51, the F-61, the F-82, which was a twin Mustang, the B-24, B-25, B-29. [Some] of that research was flying engines in icing conditions beyond the Cleveland area, up and down the Great Lakes. [Most of my research flying was] in the F-82. We were dropping ramjet [powered missiles] … over Wallops Island in the Atlantic Ocean, and on the way down [Bob Gilruth's engineers including Howard Kyle] would get telemetry data back on the propulsion characteristics of the ramjet. At that time I was working in conjunction with John [H.] Disher, who [later went to] headquarters [at] the same time [as] I.

… I got a master's degree [by attending night school at Case Institute of Technology] under Dr. [T. Keith] Glennan, who subsequently became the first administrator of NASA. Then I [received] a fellowship to Princeton for flight test engineering that the [Air Force and] Navy had primarily sponsored. [I attended under a fellowship AIAA (American Institute of Aeronautics and Astronautics)] was sponsoring. Got [another] master's degree there in flight test [engineering] and was going to [NACA] Edwards as a research pilot when I interviewed with the head of the Langley flight group at Langley, Mel [Melvin N.] Gough, who suggested that [Edwards] wasn't the place to go, because [Edwards] had undercut him, [and was becoming the primary NACA flight research center]. Being the Langley chief [pilot], he felt that [Langley] was the place to do flight research.

So I got diverted back to Lewis, where they made me [Assistant] Head of the Aerodynamics Branch on stability and control, and under Silverstein we designed a hydrogen-powered [second stage], which was to be launched on top of the Sergeant solid rocket first stage. We had that pretty well along in terms of dynamic stability and propulsion [when] Abe got a call to go to Washington to [put together a] space program because we could see Sputnik coming. Couldn't see that particular event, but we could see the space era coming, because we knew that the ICBMs [Intercontinental Ballistic Missiles] from [post-] World War II were now being [considered to launch orbiting payloads].

[Silverstein commuted] a group of us [to] headquarters, starting in mid-[1958], including George [M.] Low, John Disher, John [L.] Sloop, Newell Sanders, and myself. We worked there … for a period of six or eight months during the [Dwight D.] Eisenhower administration, in which we proposed several things to the administration in terms of what man could do next, what we should do next. Of course, the first [decision required] was what organization should take over the space business. Should it be NACA? Should it be the Army, under [Wernher] Von Braun? Should it be the Navy? So, a lot of discussion at the top levels [of government], but [NACA was] prepared to take over if that's the way the chips fell. And that's the way they fell. … Eisenhower decided it should be [a] civilian space program, and therefore the civilian agency, NACA, should be transformed into NASA and given the prime responsibility.

At that point, George Low was made the director of manned space, under [Abe] Silverstein, and I was [chief] of manned satellites … at that time, before we had a Mercury Program. [We were assigned] our background specialties under Abe's guidance, and mine being piloted flight, became manned satellites. I [was] selected, under Charlie [Charles J.] Donlan, to [interview and recommend] selection of the Mercury 7…

Fortunately, Eisenhower helped us by saying, "Let's make this simpler and more logical." … He had a little prodding from us to [select] people who had already been

qualified in high-performance jet aircraft, in particular who had gone through the military test pilot schools at Edwards, Navy [Patuxent], and Great Britain. … At that point, [his] decision [and the program's objective] was … secret… [We asked for] volunteers for a program "which would be interesting [to pilots]" and we got more than we needed. Over 110 we felt were fully qualified and we ranked [them] in terms of their experience qualifications, [then] divided them into three groups.

We sent the first group … [to] a physical exam at Lovelace Clinic in New Mexico. [It was] decided … I should go with them just to make sure that everything was done appropriately, so I went through the Lovelace Clinic [testing] with them. I came back [to Washington] and I did not go through the Wright Field test, which was more psychological than physical. … I thought that was not required, and I guess I wasn't alone in that respect.

[We interviewed and ranked] this first group of thirty [two] who had gone through [testing in five successive] weeks, [then] screened those down to seven. [They were] the Mercury 7. At that point, the Manned Space Program had been officially kicked off by Eisenhower, and so had the beginnings of the Johnson Space Center, [composed] of Bob [Robert R.] Gilruth's group at Langley, [who] had been visiting headquarters, [meeting] with Silverstein's [staff and Congress] the previous six or eight months.

… I was transferred into Gilruth's group. "As headquarters representative, you should go [to] Houston with … the Mercury astronauts," so I [moved to Texas] in 1962 with no [NASA] facilities except several spots around the Houston area here. My first office was on [the Gulf Freeway], and Gilruth was in the Farnsworth Chambers Building on Telephone Road, [where I] spent part of [my] time … before the Center was built. About a year and a half later, we moved into the Center. Building 4 was [my] home for the next ten … years.

At that point, … Walt [Walter C.] Williams had joined the group, because Charlie Donlan, who was Gilruth's deputy at Langley [Space Task Group], decided not to come [to Texas], and go back to Langley where he had started. [Gilruth] brought Walt Williams [in]

as [his] deputy, so I reported directly through Williams, … in Flight Crew Operations Division, as division chief.

[I was] involved, when I was down here, in the second selection program [primarily] Gemini astronauts, the next nine, and then following that, [in helping select] the third group [which] involved [some] of the Apollo astronauts… [I continued to be involved with Astronaut selection until 1967]. At that point my time was wholly tied up with the crew integration into the vehicles, … the training simulators, [and flight planning]. That's the way it started.

BERGEN: Tell us about the simulators that you used and how important they were in training for the missions.

NORTH: We saw quite an evolution, of course, in that time period, because in the aircraft industry, as you know, you had your option of using simulators [or] airplanes to train with. In the space business, you lost the [actual] flight vehicle [as a training device]. You had to train all the way on the simulator. So I think the space business probably did more to advance the art of simulation than anything else in the simulation world. We went from the old analog computer Mercury procedures trainer to the high-fidelity motion base we have today in Shuttle, the evolution of [digital] computer technology into [flight simulators].

Probably the most advanced thing we developed was the out-the-window view, the high-fidelity aspect … not only allowed the crew to see the Earth and the stars, but allowed them to navigate, so it had to be a precise out-the-window-type simulation. Half the money in the Apollo simulator was involved in getting the out-the-window optics perfect enough for training. So that was certainly a big step forward. We have a lot to thank in the company of Singer Link, who [developed most of the simulators and] worked with us [in Houston] in those days. I spent many trips up to Binghamton [New York] to work with them, [including]

people like Ray Long … and Lloyd Kelly, who was a pilot, working directly … with my division on the design of the simulator. They're still in the business. [They are now part of] Raytheon. I believe they merged … a couple of years ago.

The other aspect of the simulation business that became very important was the lunar landing part, which involved the Lunar Landing Test Vehicle… [We] had to simulate operation in one-sixth gravity, and that [simulator which] was flown here at Ellington Field, was initiated by the Dryden Flight Research Center, actually. They were helping us in parallel all along the way [developing operational] techniques for manned space flight. Two gentlemen out there, Gene [J.] Matranga and Dick [Richard E.] Day, [designed the] Lunar Landing Research Vehicle, they called it, which was the predecessor of the training vehicle. It had a jet engine in the center and peroxide jets around the perimeter. The jet engine was gimbaled so it stayed in a vertical position at all times, and was programmed to [thrust at] five-sixths of the weight of the vehicle even as the fuel was depleted, so it kept a one-sixth gravity dynamic environment for the hydrogen peroxide [rockets which would] tilt the vehicle [causing it to translate in any direction].

That vehicle evolved into the—we built three of the lunar landing trainers after that for crew training, with the great help of Bell Aerospace out of Buffalo, New York. As Neil Armstrong and [those who followed] said, they felt it was … that [simulator] experience that [prepared] them [to] land safely on the moon. They felt they had been there before.

BERGEN: Where were you when Neil Armstrong landed on the Moon?

NORTH: In the control center here.

BERGEN: What do you remember about that event?

NORTH: It was a great relief to know they were down safely with a very scarce amount of fuel. Of course, immediately then the thought switched over to a safe return to lunar orbit. As we all appreciated during the design phase, you [could] design in redundancy of nearly every component of the spacecraft, electronically, propulsion-wise, except for one thing, and that was the ascent stage of the lunar module. That was a single engine. It had to work. So fortunately, a day later when he took off, it worked perfectly.

BERGEN: One thing we didn't talk much about was Gemini. What are some memories you have from that program, and what kind of involvement did you have in it?

NORTH: That was an interesting program that turned out to be an extremely helpful and useful program operationally for us. As you know, in fact, when [Gemini] was … initiated, we had not chosen the lunar orbit rendezvous; we had chosen Earth rendezvous. … We were going to do Earth rendezvous before going to the moon. So the rendezvous [concept] had been chosen, but not the particular [type] that we wound up with. …That's one reason [the] Gemini Program was instigated, because … the rendezvous with the Agena target vehicle would be very similar to Earth orbit rendezvous, which [was] eventually [changed to] lunar orbit rendezvous. … [Gemini] gave a lot of practice in rendezvous, docking, separation from docking. As Neil Armstrong found out the hard way [in Gemini VIII], it isn't always [predictable].

The other thing that we discovered was extravehicular activity in space could be far more physically tiring than we had suspected on the ground. In fact, on [Eugene A.] Cernan's mission, flying with Tom [Thomas P.] Stafford, he was working in the adapter of the Gemini spacecraft, doing mechanical work, and fighting the [forces from pressurized] gloves [coupled with faceplate fogging caused by the cold of dark space, it] became so tiring that he became nearly exhausted doing work that had seemed quite straightforward on the ground,

although we had trained [some] in the water tank, not to the extent we should have. … We found that we needed to do a lot more training on the ground, in the water, to get realistic physical exertion-type motion, particularly on the hands. Gloves were redesigned at that point to make them easier to use [with] the 5 psi [pounds per square inch] pressure space suit. Those were the two primary things [which] evolved [from Gemini].

BERGEN: Did you work directly with the astronauts very much? How did your position in Flight Crew connect with what actually happened on the missions?

NORTH: My division had about 300 people divided primarily into [three groups]: one was the Simulation …, one was the Crew Integration, [the third was Flight Planning]. So much of the time was spent working with the astronauts and the contractors, to make sure that the vehicle was designed from the standpoint of manual [operation]. In the case of system failures, we could switch to a backup system, and … once you were in the backup system, you could [learn to] fly the vehicle safely. So we spent a lot of time on the simulations involving those techniques, not only in Gemini, but later in Apollo, with Marshall Space Flight Center. I traveled a lot with the astronauts in the T-38 [flying] to the various [development] facilities…

Training that we did on Apollo in the mission simulation for Apollo 13 certainly paid off, because using that [systems training familiarity], we were able to quickly investigate the various fixes for the Apollo 13 [problems] in terms of what the crew could do, what the lifetime of the propellants might be, and the battery power [without fuel cells]. Simulators worked hand in hand with the operation in space. Although not intended [for the particular Apollo 13 problems], it certainly helped in the malfunction [workaround procedures].

BERGEN: Do you feel your experience as a pilot, flying the different vehicles that you flew, helped you in your position at NASA?

NORTH: Other people [apparently] felt so, and I think that's helped [resolve] some of the [problems] we [faced]. We had a lot of extraneous input from the beginning as to what a pilot could and couldn't do in space. There were people in the aeromedical community and psychologists who felt that the crew could not operate at zero gravity. … We [believed] from aircraft experience that zero gravity [in space] was a simple extension of a zero G pushover maneuver in high-speed aircraft. Even an extrapolation of diving off of a high diving board, you're at zero gravity for a couple of seconds. Seemed like a logical extension to [a pilot], but that concept was hard to sell in the beginning.

[Some] would say that zero gravity would make the gentlemen go berserk. In fact, during the Mercury design, we were told by one [person] we had to design an automatic system which would take over if the pilot went berserk. [Laughter] So we had to fight that sort of [input] in the beginning, but that soon became passe, as soon as first flight.

BERGEN: Speaking of Mercury, what kind of impact did Yuri Gagarin's flight [1961] have on you and the people you worked with?

NORTH: We felt that we probably shouldn't have flown the chimp first. If we hadn't, we'd have been first. As you know, we flew [the chimp] before Gagarin, and then Gagarin flew before [Alan B.] Shepard [Jr.]. If … Shepard [had flown] in place of [the chimp], we would have been there first. I think retrospect shows that we didn't learn anything from the monkey flight that helped us.

BERGEN: What did you think were the greatest challenges of the Mercury Program?

NORTH: It was a very interesting period, because everybody knew that we and the Russians both had boosters that could launch ICBMs, and the logical extension from that was to put manned and unmanned satellites in space. So we felt that [man-rating the military boosters was] most important… Of course, even before that time period, people had thought about space because of the implications of these vehicles, and the German group, the Peenemunde group under von Braun, eventually wound up at the Marshall Space Flight Center under—at that time it was the Army Ballistic Missile Agency, under General [John B.] Medaris. The von Braun group was a very [dedicated] group, a good group. We enjoyed working with them. The astronauts and he got along very well, and that [mutual respect with] the astronauts was extremely [helpful for all].

We made good friends with [many] at McDonnell, on the Mercury Program: Jim [James S.] McDonnell [Jr.], the president himself, John [F.] Yardley, Walter [F.] Burke, [and] Chuck Jacobson, who later came down to Houston, headed up the McDonnell group here, which was [also an excellent] support group for the Apollo Program. So we [had] good relationships with the prime contractor not only in the Mercury Program, but that continued throughout the Gemini Program, which [then] continued with [subsequent programs]. [We also] had the influx of people like Jim [James A.] Chamberlin from Canada and his strong technical group [of] AVRO [ARROW designers], the airplane that was canceled just before the Mercury Program flew. …They were a logical group to help us, and we sure thank them. It was more of a partnership with the contractor that made the program work, I think, more than a manager-employee relationship. It was a partnership, [with] good people in industry and the government.

BERGEN: Did you have concerns about putting men in a Mercury capsule on top of the Atlas, with so many problems they had in the development of that rocket?

NORTH: You've been reading the literature. [Laughter] Certainly. We worked very closely with General Dynamics on the Atlas, and with Von Braun on the Redstone, to make sure that the escape system, which had been designed primarily by NASA, could fly on these two vehicles and separate, pull the spacecraft off in the event of emergency. That was a strong [requirement], and my initial effort was to make sure the escape system could be manually … monitored and activated, [when necessary] by the crew.

Of course, in Gemini we went … the aircraft [escape] route, [using] ejection seats rather than the escape tower, so [the crew] could eject [as in a high-speed aircraft]. That way we could eliminate the escape tower…

BERGEN: How did you feel about using the ejection seats as opposed to the escape tower? There were some people who didn't like the idea of ejection seats.

NORTH: That group was not the pilots. The pilots grew up with ejection seats, and many of them [are alive today because of] ejection seats. In fact, Neil Armstrong [was] training [at Ellington] here in the lunar landing training vehicle, [when he] had to eject [because] the aerodynamic forces of this training vehicle upset the stability … [provided] with the [peroxide] jet [control] system. … He lost control of the vehicle and had to eject…

… Ejection seats had certainly been perfected. The Gemini seat [was followed by the Mach 3 shuttle ejection seat]. We went out in the early [shuttle] days to see Kelly Johnson at Lockheed Burbank. He was in charge of the SR-71 airplane [design], which … had many of the flight characteristics in terms of mach number and dynamic pressure that we'd be facing in [shuttle]. … The ejection seats, as you know, continued throughout Gemini and into Shuttle, the first four flights, and many of our wishes would have been that we could have kept the ejection seats in the Shuttle.

In fact, we fought to do that. That would have restricted the size of the crew, because [one] couldn't put six or seven ejection seats in there of the same type that Kelly Johnson had built for the SR-71, but we could leave the two pilot seats in [then added] four [abreast] behind the pilots, that were of a much lighter variety. The Yankee escape system, which flew on the A-1 airplane, for instance. It's a tractor rocket that pulls the pilot out in a prone position, where the seat [pan] collapses and the pilot is pulled out [head] first. That would have involved putting in pyrotechnic escape hatches in four places … behind the flight crew in the [overhead] payload deck …, which would have involved redesigning the orbiter to some degree, [including] the wiring overhead.

John [W.] Young and I made several trips to try to make that system [workable] by getting Langley to help us. Langley engineers in the Structures Division looked at how you would put shaped charges in the overhead of the Shuttle. It could have been done. It would have [involved] a time delay, … been a little [more] expensive, [and added some] weight… At that time [some] people [interfacing with Congress] were saying that all you needed was four flights and you had an operational airplane… "Let's just use [seats] for four flights … If the [shuttle] works fine, we can take them out and fly it [safely] like a DC-9." Well, that, of course, wasn't quite true.

… We made some mistakes along the way… We've got a vehicle today which has a moderate [bailout] escape capability, but not nearly what some of the crew would like.

BERGEN: You mentioned Gus Grissom. In '67, the Apollo 1 fire, or Apollo 204, as it's often referred to, occurred. What kind of impact did that have on your division, since you'd worked so closely with the astronauts and the spacecraft?

NORTH: … We knew Rockwell was going to have to redesign the spacecraft. The first thing, and the longest pole in that redesign, was making the escape hatch … outward-opening …

rather than inward-opening… Of course, the reason it was inward-opening was that … it's lighter weight. It's much lighter weight to put an inward-opening hatch that seals by pressure when you pressurize the inside of the airplane or inside of the spacecraft. It's certainly the lightest way to go.

But we had never fully looked at, in retrospect, the anomalies that could happen, that would require a quick opening of that hatch on Apollo. [No one] had … foreseen the Apollo 204 fire, but we had foreseen the need to get out in a hurry, … in [an] emergency. Every [jet] fighter airplane that's ever been built, you can get out in a hurry …, either by [explosively] blowing it out or ejecting through it.

I remember at one time [it was] suggested to the Apollo Program Office, before the fire, that the hatch should be outward-opening, and I'll not go into that in any more detail, but we were told that [would make it too heavy].

BERGEN: Were you involved in any way in the investigation after the fire?

NORTH: Everyone was [indirectly], yes. I wasn't part of the team that was headed up by [J. Irving Pinkel who I worked with the Lewis Center]. [Frank] Borman … was on that team. … The main focus of their operation was to [establish] the origins of the fire, not how you could fix the spacecraft afterwards… So it was more on the electrical-oxygen[-materials] relationship [to fires] that the accident investigation focused on.

The rest of us looked at what we were going to do to change the spacecraft. Of course, the outward-opening hatch quickly became a must for the next Apollo spacecraft, and that took a year and a half, as you know, before [it could be] redesigned and [tested]…

BERGEN: Did you feel confident in the spacecraft by the time Apollo 7 launched?

NORTH: …Yes.

BERGEN: Were you involved in the decision to send Apollo 8 to the moon?

NORTH: Indirectly. I knew that the lunar module wasn't going to be … ready … for the Earth orbit mission that was planned… The command module [had] been tested with man in it. It could simulate easily the translunar mission. The reliability of the engines had been … proved. It was time to bite the bullet.

BERGEN: Did you feel confident that the astronauts would be prepared for that mission before they left?

NORTH: …Yes.

BERGEN: What are your memories of Apollo 8?

NORTH: That was an easy flight, from the crew's standpoint. They didn't go into lunar orbit, as you know. They went into Earth orbit and then injected in an escape trajectory—injected, not ejected—into the translunar orbit. It was really a challenge for the … guidance system to be able to target those in-flight maneuvers, which [it] did in extremely good fashion with the help of MIT [Massachusetts Institute of Technology] and the people in John Mayer's division in the Center. Everything worked as planned from [the] trajectory standpoint and a reentry standpoint.

BERGEN: What additional aspects of training did your division have to incorporate when you did the lunar missions, when they were actually on the lunar surface?

NORTH: We became involved … with the geologists, of course. I saw it necessary to go out to Hawaii at one time with Dave Scott's crew, to make sure that they could find the right [lunar] rocks in the Kilauea crater. It was a very interesting aspect of our training program. The astronauts enjoyed the geology, I'm sure. The experiments I did not get involved in in great detail. We were more concerned about getting there safely and doing the work safely on the surface, getting back in the spacecraft … and doing all the failure-type training that we could here in terms of the spacecraft, other than the experiments that they were conducting… We felt [the lunar surface activity was] well-managed … by the scientific community. It worked quite well. [Harold I. Johnson, in my division, had designed and built a translating overhead suspension harness which gave the Astronauts excellent simulation of walking and running under one-sixth gravity.]

BERGEN: How did you feel about the selection of the Earth scientist astronauts?

NORTH: We felt it was the thing to do. They were all good men. I had good relationships with them. I flew [in aircraft] with … them, [the first group] became pilots, as you probably know. Joe [Joseph P.] Kerwin, Ed [Edward G.] Gibson, that group…

BERGEN: How did you feel when President [John F.] Kennedy announced that we were going to go to the moon and back before the end of the decade?

NORTH: We had some inkling of it because my bosses had made those overtures to President Eisenhower, who was somewhat lukewarm. But when Kennedy was elected, as you know, … Abe Silverstein [and Hugh Dryden] had made approaches to the White House [Space] Committee under Lyndon [B.] Johnson [and convinced him] that the Apollo Program was the

thing to do, man landing on the moon. We knew that the seeds had been sown; we weren't quite sure when they'd germinate. It was gratifying that Kennedy did it soon after Shepard's flight. It invigorated everybody to work harder. For the next [five or six] years, I don't think anybody took any annual leave and no sick leave unless we were really sick. I didn't. When I retired, I had 2,000 hours of sick leave I hadn't used. [Laughter] Lost [most of my] annual leave.

BERGEN: You mentioned your boss, Abe Silverstein, several times. Tell us about him and your working relationship with him.

NORTH: Extremely sharp, capable engineer and manager [and good at projecting technology into the future]. He had a bachelor's degree in mechanical engineering, as I recall, from Rose Poly Tech in Terra Haute, Indiana, which people don't normally think of as an outstanding engineering school, but it certainly [developed on in Abe]. He became father of propulsion, as far as I was concerned—advanced propulsion. He [recently received] the Guggenheim Award, as you probably know. It was awarded to him about a year ago, which is a very prestigious award for all of the work he's done primarily in propulsion, but also in the [overall] space program. He had not only hardware knowledge, but he could look into the future and see what [could] be done ten years from now. We took the lead from him.

BERGEN: Do you have any other special memories, or anything that we didn't talk about, from Mercury through Apollo, that I didn't ask you questions about or you haven't mentioned yet, that you'd like to share.

NORTH: I think probably most of our work, of course, hopefully was done when they lifted off, … the [spacecraft] familiarization and crew integration… My division then had little to

do [if everything went well]. They had written the flight plan and had laid out everything, how it should work [and conducted the training]. So when we had the problems, that training paid off.

On Apollo 13, I recall that … Tom [Thomas K.] Mattingly, who had originally been scheduled on that flight, [then] was exposed to chicken pox [or measles] and was grounded, … was available [to trouble-shoot because he had studied the systems] … thoroughly. He knew the systems. He knew the procedures. He came over to the mission simulator and we worked three days, seemed like night and day, to look at all of the fixes that were being proposed, the impact it had on the mission and was it practical. It [was] an extremely useful tool. Without that simulator, we would have had a rough time pulling it off as it was pulled off. That crew might still be in orbit somewhere.

BERGEN: True. How did you feel when Apollo 17 launched and you knew the Apollo Program was ending?

NORTH: [Chuckles] At that point I was heavily involved in the Shuttle Program, and I felt that we were over the hump in Apollo after Apollo 13 and 14. We, of course, [continued to work Apollo] heavily, but we had shifted part of our division's effort into Shuttle and we were hoping the Shuttle would materialize as quickly as we thought. We could foresee the Skylab missions coming. … We did not foresee the Apollo-Soyuz at that point. That came … as an afterthought during Skylab.

The Center was really stretched, as you know, in those days. [At one time,] we were [working] Mercury, Gemini, and … Apollo together, and looking at Shuttle somewhat in the same time frame, although Mercury was finished in 1962. … There was a lot of overlap, and I was heavily involved in all phases of it. I was fortunate to be involved in all phases.

BERGEN: In 1971, you were moved to the position of assistant director for Space Shuttle Flight Operations Directorate. How did you get moved into that position, and what were you responsible for?

NORTH: You asked before about Apollo 17. This [move] occurred before Apollo 17, as I recall. We were trying to shift gears and pick up the Shuttle… I had [major] interest in how the experience from [lifting-body programs and X-15], from [NASA and] the Air Force, should feed into the Shuttle design, many different configurations being considered. At that point, three excellent people that were working with me [in] Flight Crew Operations, Dean [F.] Grimm, [J. W.] Bilodeau, and [Carroll H.] Woodling, … were all made division chiefs.

My division was split up into those three divisions and I worked under [Kenneth S.] Kleinknecht in the beginning, and worked with John [W.] Young probably more than anybody in the crew integration phase of Shuttle, what the crew could do, should do, in Shuttle. Visited many of the contractors, … Langley, the Dryden [people], [and the] Air Force… That was a busy time in the Shuttle formulation phase.

BERGEN: What were some of the issues that you were involved in?

NORTH: Started with the configuration, what could the crew do. It was a foregone conclusion that the Shuttle was going to be more like an airplane than a ballistic missile warhead. We knew it was going to have some kind of wing; we didn't know how much. The L/D, lift-over-drag ratio of the X-15 was something that we knew [pilots] could handle… [Armstrong and Joe H. Engle had flown the X-15.]

It turned out that the Shuttle has the same lift-to-drag ratio as the X-15, although an entirely different configuration. Therefore, the same flight [angles-of-attack] would be required to be able to safely fly … and land it unpowered, although in the beginning the first

configuration … did have air-breathing engines that would extend out from the sides after deorbit and be used in case a go-around was required on landing. But after looking at the X-15 experience and the landing [footprint], … you would have coming down from orbit with the kind of lift-to-drag ratio that we had, felt that you'd have to be awfully far off target before you couldn't land at a prescribed point after deorbit with the lift-to-drag ratio of the X-15. … So far it's worked very well. The only problems we've had have been weather, of course, on landing. With two alternate fields, you're covered. So that was the first phase.

The second phase was what degree of redundancy do you need in the flight control system. As I recall, General Abramson came on board in headquarters about that time, manned space flight chief. His experience [with] the F-16 [development was valuable]. He was the F-16 program manager in the Air Force.

That airplane had a fly-by wire system, no control cables directly to the servos, so we [had] that experience, although it wasn't good in the beginning, the F-16 had some accidents, as you may know, in the early days because of problems with the fly-by wire system. … [The pilot input] a signal which [was modified] before it went to the [control surface] servos, so the position of the elevator wasn't necessarily what the pilot was calling for. [It] was what the computer [was programmed to] handle, and it led to some accidents in the F-16 because the software designers could not [foresee and] design [software for the anomalous flight conditions] the airplane could [experience].

That's [also] happened in some of the civilian aircraft accidents, … the autopilot has put the aircraft in the position where the pilot couldn't recover. … I think some of the European Airbus early accidents were due to [an] autopilot [which placed] the airplane in the [attitudes] where the crew couldn't recover [with a fly-by-wire control system]. So we were quite concerned that the fly-by wire system had to be very carefully designed and checked out, and the software had to be [compatible with] any condition that could arise. And with that so-called guarantee, we went ahead with the fly-by wire system… It's worked very well.

… The brakes on the airplane … have been upgraded since the beginning. A … drag chute was an add-on afterwards to give you more [landing] margin. But a big concern was [inflight] crew safety, in my mind, and how do you get away from the vehicle in the case of emergency, particularly during launch. We learned the hard way that we weren't quite ready for that kind of an accident, and I hope we move in the right direction. It takes more than four flights to become operational in this high-risk business.

That's what I think is going to continue to be with us as higher propulsion system performances like the … engines are putting out. The ones we have on the Shuttle today [operate at] 3000 pounds per square inch, which is a lot of pressure to harness. A lot of chances for a leak [during launch]. It would be catastrophic. We've been extremely lucky in the main engine category. … The solid rocket [has] had [the] critical [inflight] problems so far.

BERGEN: Were you involved in developing simulations for the Shuttle?

NORTH: Yes. Used a lot of outside help in that regard. We used [Cornell's] Calspan inflight training airplane, what they call the TIFS [Total Inflight Simulator], which [their pilot Bob] Harper flew… [TIFS was the forerunner of the Gulfstream II Shuttle Training Aircraft used today.] We used a lot of experience from the simulators at Edwards, from the lifting bodies, the X-15 simulations [are] very analogous to our final phase of our flight. Bob Hoey at the [Edwards] Air Force [Base] was a big help and was heavily involved with the lifting body [and X-airplane] program simulations, as was Dick Day, who was my assistant division chief… All that experience was extremely valuable in [knowing] what the Shuttle … should be [designed to emulate]. Moving base visuals were just an outgrowth of what [had been] done before.

BERGEN: How did you feel about the first STS-1, the first Shuttle mission, being manned as opposed to being unmanned?

NORTH: [Laughter] That was the way it was designed, and that's the way it [flew]. It worked very well. There was during the design phase much speculation as to how much of an autopilot we should design into the airplane in terms of the automatic landing system. That debate flourished for several years during the evolution of the Shuttle, and it was finally decided that it had to be [a manned landing], because automatic landing was too big a step to [qualify using today's procedures], although the Russians did it later. [Theirs] was more of a [one-time] stunt than a real thing, because that's the last and only flight they ever had in [their] Shuttle.

BERGEN: What do you feel were some of the biggest challenges in your job in the development of the Shuttle?

NORTH: I think I've reviewed most of those. I was just using the experience in industry and the Air Force and Dryden to build on, the lifting body program, X-15. I had known these people from NACA days, had been out there many times for conferences, and we'd given papers together on various aspects of aircraft flying. So I knew who to contact at Dryden. We'd previously known each other. So we introduced the astronauts to them. Of course, [some] of them that had gone through the Air Force Test Pilot School had grown up with [those troops] also, so it was a natural cooperation and partnership with Dryden [and the Air Force], as far as I was concerned.

BERGEN: How did flight operations differ in Space Shuttle from Mercury through Apollo?

NORTH: Certainly became more refined and more precise in all aspects, from hardware to the simulations, to the operation, a logical evolution in a ten-year period. Got a lot of experience to look back on now as we take the next step, as to what can and can't be done. … The [plans] that I've read about, that the Augustine Committee has recommended seem pretty logical in terms of the next step.

BERGEN: The Challenger accident happened after you retired. Were you involved in any way in that investigation?

NORTH: I was called back by Eagle Engineering, who had a contract to look at implications of the accident in terms of design and what they could do and should do next, and things crew safety-wise that we had talked about before were reviewed there.

… The configuration we have today is … a compromise of what we would like to see, but certainly a step in the right direction. … The current configuration will allow a crew to get out under a stabilized flight condition if they can't make the landing field, but it will not enable them to get out during a serious malfunction where the [vehicle] is tumbling. [It is believed] the crew was probably alive in their Challenger crew cabin until it hit the water, so if they'd had parachutes and a way to get out, they could have saved themselves. … That exact accident will never happen again, but something equally as catastrophic might. So we hope we've taken a big enough step in crew safety.

BERGEN: How do you feel about the privatization of the Space Shuttle?

NORTH: I think we learned from the Manned Space Program that the private industry [has] really got a heck of a lot of capability. In fact, they have all of [the manufacturing capability

and a lot of operational smarts], as far as I'm concerned… They have to be heavily involved in the design and operation. It's a logical step.

BERGEN: Where would you like to see the Space Program headed in the future?

NORTH: That's a good question, in view of the cost limitations we have. [Budgets] seem to vary from week to week and from President to President. But then I think that the [recommendations from] the Augustine Committee …, from what I'm aware of, is that you need to focus the effort on people whom you know have the background to carry it through. That was, I think, what happened in Apollo, that people like Silverstein and Gilruth and George Low had the background to know who to call on, when to call on them, and how they could work with private industry. So it was a great partnership effort between the people that could do it.

I think we had trouble with headquarters from time to time, [depending on the background of the people] there. The lead center concept certainly worked out well, as far as I'm concerned, where you focus the responsibility on the people who have the background. If you try to dilute that too much, you can cause problems in [extraneous effort] communications delays and expense.

BERGEN: Looking back over your entire career in the space industry, what do you feel you're most proud of?

NORTH: That I was born when I was: [Laughter] I don't think there's any other time in our history that one's lifetime could span as much progress as we've seen in aviation, from World War II, where [aircraft development] and [rocket performance were top priority], and the aftermath of World War II, what it meant in terms of the Cold War competition with [aircraft

and rockets], and certainly the computer coming [of] age. The computer has done a lot to enable small, compact [systems] to navigate to the moon and back. It's an exciting time to live in.

BERGEN: How do you feel about us working with the Russians now, when in the rest of your career we were in competition with them?

NORTH: … I think the astronauts did an extremely good job of bridging a [communications] gap which [revealed a high level of expertise in Russia]. The Russians are … good engineers and build airplanes that are extremely good. They put all their money in airplanes and defense, and that's [how] their [economic] problem [developed]. They spent all their money that way and not on the things that would have let them have a free-enterprise economy like ours. [Because of their current economy] it's going to be difficult for us to work with them, I'm sure, in the future.

My concern is—and I'm sure I'm not alone—with their decreased funding, that [some of] the hardware we're depending on over there, including the [launch vehicles], are going to be extremely old and perhaps not as well maintained as [everyone] would like. From a crew standpoint, depending on what [exposure] the crew [has to this hardware], it could be hazardous. … We're subsidizing them heavily on many parts of that program. [The joint program is] going to have to be scaled back [because] their monies are not going to be forthcoming as we had hoped.

Butler: I have two questions for you. Looking back, when you first became involved with both the Air Force and then NACA, could you have ever imagined where it all would lead and what it would involve?

NORTH: No, I certainly couldn't, and I didn't. My good fortune was, I was working with people like Silverstein, who could foresee things. Afterwards, in reading history, I realize that the Russians and the Germans, as well as Professor [Robert H.] Goddard, had thought about rocket flight long before World War II. So it's good that we had that foresight back that far and some of the groundwork had been plowed… We just built on that.

I'm extremely thankful that we had the Germans under von Braun working with us in the Space Program, the big boosters in particular. That background was extremely valuable. The V-2 and V-1. The V-1 rocket, incidentally, the Germans—their crew safety contact [at Marshall] was a gentleman by the name of Jack [Joachim P.] Kuettner, who is the only man who ever flew … the V-1 buzz bomb. He had some wild stories to tell about that. That was the noisy pulsejet [which] flew over London and scared everybody to death with its noise as well as its warhead.

But von Braun's group was certainly a big help to [the NASA space program]. It was a tough team to beat. I hope we can [continue to work with them. Marshall also had many good American-born engineers such as Lee James and Jim Odom.]

Butler: You talked about Abe Silverstein. Are there any other individuals who you worked with closely that you'd like to say anything about?

NORTH: I can give you a long list. I really can. I was in a position, working with the astronauts, that we visited … the contractor facilities and soon got to know [their people], most of the [prime] contractors, fairly well.

To start with McDonnell, John Yardley, Walter Burke, Chuck Jacobson. With Gemini booster was Buzz [Bastian] Hello, at that time he was with Martin and later went with Rockwell. At Rockwell we [worked with] Charlie [Charles H.] Feltz, Dale [D.] Myers, [aircraft] experienced, good people to work with. In the Air Force we had General

Abramson, General Davis at Patrick [Air Force Base], who [was in charge of water recovery] in the early [pre-shuttle] days… At Cornell Laboratory, [was] Bob Harper [who developed the Cooper-Harper aircraft ratings with George Cooper at Ames]. At Ames Research Center [was] Gordon [H.] Hardy, one of their test pilots who worked with us on their simulation. At Langley [was] Paul Holloway [and] [W.] Hewitt Phillips, who you've probably read a lot about. Larry Bement in the Structures Division, who worked with us a lot … looking at escape systems.

At Cape Kennedy, we had people like Sam [Samuel T.] Beddingfield, and … [G.] Merritt Preston's [NACA] group, who I worked with in Cleveland, [including] his crew chiefs … Frank [M.] Crichton, the crew chief of the F-82, which I flew at Lewis, and Joe [Joseph] Bobik, crew chief on the F-61, which I flew. It was like old home week in some regards, that [we] were able to stick [together] through the Space Program. All had aircraft backgrounds, which [was valuable during space vehicle integration and operation].

BUTLER: You are still out and about, involved in different programs. Would you tell us some of what you're working on now? You gave us a brochure.

NORTH: [When I moved to Houston, I] had children who were starting school. I discovered a [good] reading program at Alvin, Texas. I was living in Friendswood at the time. It [was] the Spalding reading method of using phonics to teach reading to elementary students, … although it works with adults. The program was being taught in Alvin, not Friendswood, so we carpooled our children into the Alvin school system. … I talked George Low into having his children join us, so we carpooled together. His two children and my two children, oldest children, went to Alvin for about two years.

Mrs. Spalding [had developed the reading] program. I had met her along the way [and] told her when I retired I'd like to help her, because I knew the reading [proficiency] in

this country and the reading capability of [graduates] from high school and college was very low. … Many high school and college graduates [are not] able to read well. In fact, some [are] still illiterate, [having] been pushed through school. [After retiring from NASA in 1985 I helped Mrs. Spalding organize the Spalding Education Foundaton.]

The program we have is to train teachers [throughout this country, Canada, and Australia] to teach this phonics-based method of reading and comprehension, so when children graduate from high school and college, high school primarily, they really know how to read [and comprehend]. … That's been my involvement in the last ten years. We know that we need good engineers and science people who [must] be able to read [research, and technicians who must be able to comprehend technical manuals]. It's been gratifying to know that our program works, and we're seeing high test scores from the schools that have incorporated it.

BUTLER: That's wonderful, a very beneficial program.

NORTH: Keeps you busy.

BUTLER: And that's a good thing. Thank you.

ROLLINS: When you were a little boy, what did you want to be when you grew up, or how close did you come?

NORTH: My life was, I guess, affected by [Charles] Lindbergh's flight. I was five years old at the time when he flew [alone] across the Atlantic. [That created an interest] in model aircraft-building. I wanted to design aircraft engines. For [this] reason I bought an aircraft engine book when I was in early high school, devoured it. Not unlike [these] days,

Lindbergh's flight [was] kind of like our [space program]. [They both] started a lot of things rolling, a lot of [new and worthwhile] interests among people.

ROLLINS: Was he your greatest hero?

NORTH: At that time, surely was.

ROLLINS: Do you have any other heroes?

NORTH: A lot of the people I worked with—Silverstein, [Gilruth], Low, Sam [Samuel C.] Phillips, the contractors, are all heroes. The astronauts, of course, but they've already been recognized.

ROLLINS: It's those people who are behind the scenes that most of the American people don't know anything about. If it hadn't been for you folks, man wouldn't have walked on the moon. So we appreciate all you've done for us, and coming here today, too.

NORTH: Thank you for inviting me.

BERGEN: Thank you very much.

[End of Interview]