ORAL HISTORY: Ralph Strong

About Ralph Strong

Ralph Strong was born and raised in Northeastern Ohio, growing up on a farm in Deerfield. He continued to help run the farm while he completed his education at Kent State University. There he pursued a major in physics and minors in math and biology. Graduating in 1950, Strong had a variety of jobs, including an electrical engineering position with the Air Force, over the next few years. Following the end of the Korean War, he was drafted into the Army. After serving for two years, Strong joined Westinghouse. He was assigned to work on the BOMARC missile and remained on this project until its end. Next, Strong managed the test program for the Gemini Rendezvous Radar. After spending some time working on the Advanced Technology Satellite program, he assisted in the modification of B-57G bomber radar for use in efforts to stop traffic on the Ho Chi Minh trail. Although this project incurred several setbacks, Strong remembers it as the most fun of his jobs at Westinghouse. He then moved on to lead a series of diverse projects, working on everything from meteorological sensors in the sky to radars for studying the oceans. Since his retirement in 1991, Strong has been an enthusiastic volunteer for the Smithsonian National Air and Space Museum Archives and his retirement community.

In this interview, Strong discusses his work history, which spans over four decades. He covers both his early work experiences outside of Westinghouse and his many jobs within the corporation. Strong talks about the successes and failures of a number of major Westinghouse programs on which he worked, including the BOMARC missile program, Gemini Rendezvous Radar program and Seasat program. He also comments on the development of technology and collaboration with government agencies and other contractors. Finally, Strong describes his experiences on the farm, in the Army and with the Smithsonian, reflecting upon their relationship to his engineering career.

About the Interview

RALPH STRONG: An Interview Conducted by Frederik (Rik) Nebeker, IEEE History Center, 14 October 2010

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Interview

INTERVIEW: Ralph Strong
INTERVIEWER: Frederik (Rik) Nebeker
DATE: 14 October 2010
PLACE: National Electronics Museum, Baltimore, Maryland

Background and Education

Nebeker:

It’s the 14th of October 2010. I’m at the National Electronics Museum talking with Ralph Strong. This is Frederik Nebeker. Could we begin with where and when you were born and a little bit about the family that you were born into?

Strong:

Sure. I was born in Northeastern Ohio in a little town called Deerfield. I attended Deerfield High School which has all twelve grades there in one building.

Nebeker:

How large was Deerfield?

Strong:

I graduated in a class of eight. Normally, it was a little larger than that, maybe twice that large. But the government built a dam around 1939 or 1940 which took up about a third of Deerfield Township and that diminished the population. And then of course, these were the war years and those seventeen and eighteen year olds that normally would have been in high school but didn't look forward to an academic career of some kind disappeared into the service.

Nebeker:

I see.

Strong:

There were only two boys in the class and six girls. And let's see. We were back there for the 50th anniversary and there were still six of the eight were at that session.

Nebeker:

You said 1939?

Strong:

I graduated high school in 1946.

Nebeker:

Oh, you were in high school during the war years.

Strong:

The war was just over when I graduated.

Nebeker:

And it had taken some of the kids into the service?

Strong:

Right. In fact there were some who went to the service and then came back and finished high school the following year.

Nebeker:

So you graduated in ’46?

Strong:

'46 from high school.

Nebeker:

Tell me about your family.

Strong:

I have a brother and a sister. My brother ended up as a college professor at the University of Wisconsin, specializing in vocational education.

Nebeker:

Was he an older brother?

Strong:

An older brother, about five years older. My sister, who was eight years older, married an orthopedic surgeon. She still resides in Cincinnati, Ohio.

Nebeker:

So, you grew up on a farm?

Strong:

I grew up on a farm. I milked cows morning and night. I went to school. In fact, the first two years in college at Kent State, I commuted. And did tours before and after.

Nebeker:

While you were keeping the family farm running.

Strong:

Right. My mother was a school teacher. My father was unusual for that era, in that he had completed a high school education. That was unusual in that era in the country.

Nebeker:

Well, earlier in the century, ten or twenty percent of the population got high school degrees. It was not that common.

Strong:

Right. So, anyways, it was never a question about going to college. It was just assumed from day one. So I attended Kent State, intending to be a science teacher.

Nebeker:

Were you interested in science as a kid?

Strong:

Yes, very much so.

Farming and Technology

Nebeker:

Someone told me that being on a farm sort of made you interested in science and technology because you were dealing with a lot of technology.

Strong:

Definitely. You know… you do things, you see the results. You plant things, you notice differences if you treat things differently. Of course animals are always a big factor.

Nebeker:

Well, then all the farm technology. All these pieces of equipment.

Strong:

You learn to make do. You learn to make repairs with wire.

Nebeker:

And you understand the technology because you have to handle it.

Strong:

Right. We had an old Case tractor that took a lot of care and feeding. We kept it going during the war years. It had a big, fifteen inch first reduction gear that lost teeth every once in a while and they were no longer available. During the war years, you couldn't buy the gear. We had to take it down to the local welder. Put on weld material and then file it down into the missing tooth. Sometimes we could make it work and sometimes we couldn't.

Nebeker:

So you were working on the farm during the war years, as you were going to school.

Strong:

Oh yes, my father worked during the war years, the early war years, he went out as a carpenter and built barracks over in Pennsylvania. So that left me to run the farm myself. At times we had a live-in, a slightly older fellow and we did what we could to keep the farm running. Of course the farm shrunk by a big factor because of the new lake, and that took some of our property. So it was only about 70 acres at that time.

Nebeker:

How many cattle could you maintain?

Strong:

We had about fourteen cows to milk.

Nebeker:

I know that's not something that can be neglected, but you managed to start at Kent State?

Strong:

I went to Kent State. I graduated there in 1950 with a major in physics and mathematics minor. I earned a biology minor, too.

Nebeker:

So you managed to do that in four years even though you were still helping out.

Early Work Experiences in Metallurgy

Strong:

Right. I intended to teach, but I didn't really find anything. I was graduating at the same time as many veterans. They had much more experience. They were more mature. So competition was tough in 1950. I took a job at Republic Steel for the summer. And they hired four of us.

Nebeker:

Where was that?

Strong:

In Youngstown, Ohio. They hired four of us to use a thermocouple to measure the temperature of the open-hearth steel just before they tapped it. It was a new technique and it was our job first to make it work.

Nebeker:

How did you get the thermocouple where it needed to be?

Strong:

We had a fourteen-foot pole. It was wrapped with about an inch of asbestos tape, and held in place with a wrapping of wire. Then it had little bit-head on the end of it, and we built that up with chrome ore and fired it into a curved head. There was a conduit through the center with a graphite plug that went into the end with a small silicon tube made out of quartz. It was a platinum iridium thermocouple and if you very carefully got the point against the quartz tube, it would last for fourteen seconds — just long enough for a Brown recorder to give a reading. The job was to make it work and then to persuade production personnel that it worked and persuade them to use it. It was about a nine-month process.

Nebeker:

It was important to have a temperature reading.

Strong:

It was open-hearth steel, and I don't think anyone realized that the temperature was about 2850 degrees Fahrenheit with a very close tolerance. Lower than 2830 and they would miss their analysis completely because too much of the steel would freeze out before they got it poured into ingots. Much over 2860, and they'd miss their analysis because the stuff was boiling out of the meld. It was a very narrow range. And I don't think they really recognized that until we started marking those kinds of measurements.

Nebeker:

I see.

Strong:

But it functioned. We had a few misses at times. And by the time I left there, after about 9 months, most of the production foremen were using it.

Nebeker:

But there was no future for you in the company?

Strong:

Well, there could have been. There wasn’t in the long term because Republic Steel went bankrupt about ten years later. There was not really a progression established for that position, and it was kind of funny because the unions were after us to join in the production crews, and the metallurgy department wanted to avoid that, of course.

So, there were opportunities in the metallurgical department to move in that direction once we finished, but I happened on an interview at Battelle Memorial Institute in Columbus, and they offered me a job. I went down and worked mostly working in metallurgy. We were arc puddle melting small ingots of titanium. The job was to explore all of the alloys of titanium.

Nebeker:

So, you used some kind of an arc furnace to melt the titanium and then alloy it with something?

Strong:

We had a little arc furnace and a copper crucible. We flooded it with lots of water to cool the outside and it was puddle melting technique, so we would strike an arc on a material inside the copper kettle and operate it until the ¾ pound ingot was made.

Nebeker:

So it was an arc to the titanium?

Strong:

We had a little prism arrangement so we could see what we were doing.

Nebeker:

You were controlling that electrode?

Strong:

Yes, by hand. Another side to that was some research in molybdenum and there we were using arc melting in a high vacuum.

Nebeker:

Because it’s reactive?

Strong:

Very, very much so. What we were trying to do was get molybdenum to a purity of I think 0.001 or something like that. Very, very pure molybdenum. But that was in a big vacuum chamber, and we had a robotic way of lowering the probe.

Nebeker:

You found some interesting work in your first couple of jobs.

Engineering for the Air Force

Strong:

I went from there to the Air Force in Wright Field. And that was a big switch. And they hired me as an electronic engineer.

Nebeker:

What was your training at Kent State that allowed you to get such a position?

Strong:

Well, you know, I ended up thinking that maybe a degree in physics was in some respects superior to one in engineering because, at least in that era, they took a much more fundamental approach.

Nebeker:

I know a number of engineers who decided to major in physics for that reason. But an employer has to be convinced that you're an engineer.

Strong:

Jobs were pretty plentiful in that era for technical people. I had one course in electronics, in the physics program, and that was to permit you to design an amplifier or some piece of electronics so you could run a physics experiment, as an instrumentation. The physics prof, as I recall, didn't really like that because he couldn't start with F = MA and get results. That particular course was interesting because several of the students had been electronic technicians in the service and they probably knew more on a practical basis than the professor did. They took him to task once in a while.

Nebeker:

What were you doing with the Air Force?

Strong:

With the Air Force, I worked originally in what they call the CNN Lab (Communications and Navigations Lab), and then later that was merged with the Radiation Lab, so the radars and communications were kind of blended together and worked closely. Our section was responsible for contractors' installation of equipment in airplanes.

Nebeker:

Communications equipment, sensors and radar?

Strong:

Communications equipment, radar, navigation: all of those things. How they were installed, particularly, antenna patterns and radomes and so on. It was sort of pseudo-engineering in a sense but I learned a lot about black box engineering there. And, we worked on airplanes like the C-124. I cut my teeth on a C-46.

Nebeker:

What kind of plane is that?

Strong:

It was a transport. It was the biggest work horse for hauling things over the hump from India into China, during World War II. It was a Curtis-Wright airplane. We took the World War II electronics out and put Korean War-era electronics in. It was a pretty extensive mod and we wrote handbooks so that that same mod could be made on all the other C-46s and bring them up to date for the Korean War.

Nebeker:

Did that work out?

Strong:

Yes, the contractor ended up building kits and going to the field and installing the equipment. I got to see quite a few airplane factories and see how they worked and it was a good experience.

Nebeker:

So, you worked on all the electronics for that, the communications, navigation and radar?

Strong:

Yes. I even got into ECM in some cases, and IFF.

Nebeker:

They had some countermeasure equipment on that plane?

Strong:

Well, no. I worked on some other planes. One interesting project was on a C-54. We chopped about four feet off the wing tips and installed an array of little antennas that would look at fifteen-degree sectors so it had three hundred and sixty degree coverage. I forget the name of that equipment. It was a simple detector, but it would give you some idea of the frequency and direction it was coming from, and this was done for some intelligence people to fly around the periphery of Russia.

Nebeker:

So it got the direction of any transmission they picked up.

Strong:

Yes, they were trying to see location and frequency of the Russian radars that were some place around the border. It was kind of an interesting experience working with them; it was the first time I touched based with any of the intelligence people.

Nebeker:

You were a civilian working for the Air Force, right?

Strong:

Yes, but I got drafted after Wright Field. Once the Korean War was over, I was no longer essential.

Nebeker:

So you had gotten a deferment in those years.

Radar Training and Teaching in the Army

Strong:

I had a fairly nice experience in the Army. They sent me to Fort Monmouth for the thirty-three week radar repair school and then they picked some of us to go down to Aberdeen to teach radar in the Ordinance School.

Nebeker:

Could I get you to tell us a little bit about Fort Monmouth and the radar school there? How it was in your experience?

Strong:

It was very well run. I got to live off base, of course; I was married. They were reasonably flexible with us because the school was thirty-three weeks. The first half was roughly fundamentals. At that point I probably could have taken a test and skipped fifteen weeks of it, but what's the point? I did learn some things. In the second half, we worked with hardware, specifically repairing selective radars. The one that they used as a training aid most was the SCR-584, like the one we have out here on the floor, and it was a beautiful radar to work with. It was roomy, spacious and you could walk through it and find problems almost to a single stage of amplification from the gages. It's very classically built.

Nebeker:

Wasn’t Fort Monmouth where the Army was doing some of the most advanced work in electronics?

Strong:

Yes, it was one of the research centers for communications. The school was somewhat separate from that. In fact, they even had a pigeon loft when I was there and they had several World War II heroes left.

Nebeker:

Was it your civilian job or some aptitude test that got you assigned to the radar school?

Strong:

I never figured that out exactly.

Nebeker:

I’m glad the Army did the right thing.

Strong:

Yes, I was glad too. It came out of the blue. We finished basic training and then got orders for Fort Monmouth. I knew several people who had enlisted specifically to get in that school who were friends by that time. I guess the earlier education and experience got me the assignment.

Nebeker:

That must have been one of the best assignments a person coming out of basic could get.

Strong:

Yes. Of course they had the S&P Corps (Scientific and Professional Corps) at Aberdeen. They took a lot of college graduates that got drafted and put them in scientific professional positions. And there were a number of those at Aberdeen, but they didn't fare as well as we did as instructors.

Nebeker:

So you had this thirty week training at Fort Monmouth and then you say you went to Aberdeen?

Strong:

Yes, we went to Aberdeen and we taught the M38 Skysweeper. We taught repair.

Nebeker:

What is that?

Strong:

It was a gun. I guess was a ninety-millimeter gun integrated directly with a radar set.

Nebeker:

An anti-aircraft gun.

Strong:

It had a hydraulic control for azimuth and elevation and it was designed to protect from low-flying airplanes that were low locally.

Nebeker:

So, you were saying it was integrated – if the operator spotted a target with the radar, it aimed itself.

Strong:

It directed itself to the target. And I think it fired automatically. It had two or three people in the crew: one to load shells and one to operate the radar. And then they also had an optical director they could use for smoothing function. The school was also teaching the M-33 and I got involved a little bit with that one.

Nebeker:

How did you get selected to be an instructor?

Strong:

Well, you know the way the Army schools work, the people with the best grades get the first pick. So, you worked hard to get the best grades so you could pick your assignment. And, so we got to the assigned room where they were going to be assigned. They read off a list of about fifteen of us and said, ‘now you’re already assigned.’ We didn’t get any choice. So then they had already picked us to go either to Aberdeen or to Huachuca to teach. Again, no choice.

Nebeker:

How was that teaching at Aberdeen?

Strong:

It was good. The school was good. It was well run. Good bunch of kids going through.

Nebeker:

And you liked the work?

Strong:

Yes. We weren’t pushed too hard. We had plenty of time to prepare and there was a lot of teaching.

Nebeker:

How long did you do that?

Strong:

That was about a year.

Nebeker:

Completing your service?

Strong:

Right. I was in just for two years. Almost all of it was either going to school or teaching school. At the end of that tour, since they had a big scientific and professional corps there, and a lot of instructors from the Ordinance School, there was a lot of activity. Companies sent teams in to interview every six months or so there.

Nebeker:

The people who would be completing their service?

Strong:

They were completing their service. So anyway, I interviewed for many companies there, and ended up choosing Westinghouse at the end of that.

First Job at Westinghouse: The BOMARC Missile

Nebeker:

What were you hired to do at Westinghouse?

Strong:

My first job at Westinghouse was on a BOMARC target seeker.

Nebeker:

Can you tell us what that was?

Strong:

Okay, a BOMARC missile was a rocket. It was for long range, anti-aircraft activity. The BOMARC would take off, the original one with the liquid fuel rocket. And fly to sixty or thousand feet or so. Then the ramjet engines would work at that speed – it was fast enough for the ramjet engines – and it would fly to the vicinity under the direction of, say, a SAGE radar or whatever was available. Then the target seeker would lock onto an incoming bomber and dive on it, and it got close enough that proximity fuse blew up.

Nebeker:

The target detection and seeking – that was in the BOMARC. Was it automatic?

Strong:

It was all automatic. As an example of that, we had a home on jam mode. We tested dozens of them down at Eglin Field. The Air Force had two B-47 aircraft equipped for drones. They were pretty expensive at the time. The B-47 would fly as a drone. It was modified as an ECM platform. So, we had the first flight against them and no one expected it to get close enough to it for a direct hit, but the target BOMARC got a direct hit and took it out.

Nebeker:

Were you part of the team at that point?

Strong:

I was part of the test operation. I was not at Eglin at the time. My job there was in the test and evaluation section for BOMARC, and we'd pretty much go between the design engineers and the test equipment designers and the factory, and spent many, many hours, doing shop follow. Solving test problems in the factory and going back to designers and telling them 'this isn’t working, we've got to fix it.'

Nebeker:

And how did that project go?

Strong:

They were deployed. We built several hundred of them and they were deployed. The most exciting part was the second version of it, which was the first airborne pulse Doppler radar. That was the DPN-53.

Nebeker:

This is on the missile?

Strong:

Right. Self-contained on a missile. Of course, the first version – the A version – was a pulse version. You had to cut off the range so that it didn't see the ground. So, it did not protect you against low flying airplanes as you wouldn't see them against the clutter of the background.

Nebeker:

So, you knew the elevation of the missile and so then you'd restrict the range.

Strong:

Right. It flew straight and level at around 60,000 feet, and it was looking pretty much straight down. But to solve that problem, we developed a pulse Doppler radar, which allows you to search for it in velocity and frequency rather than in range.

Nebeker:

The Doppler gives you the speed of the target?

Strong:

Right.

Nebeker:

So, you could look for something that's moving?

Strong:

Something that's moving versus the ground, which is moving at a different speed with respect to the missile.

Nebeker:

Were you in the test part of that?

Strong:

I still was in the test area there, system tests. And during development they had a prototype up on a rooftop lab and as soon as they figured out they solved the problem, we'd get change notices and get them worked and then put them in the production version and try them out there to make sure that they still worked. And then, as the design matured, we worked to get them through production and solve all the problems that came up during tests. So, I was kind of the last Mohican off the pulse Doppler radar, the DPN-53 program. The designers went on to bigger and better things and I was one of the last two or three engineers to get out the door.

Nebeker:

So, that BOMARC missile was going to be produced for a certain period of time.

The Gemini Rendezvous Radar

Strong:

Right. It was over about a five year period. And, from there I went to Gemini.

Nebeker:

What is that?

Strong:

We built the Gemini Rendezvous Radar.

Nebeker:

For the Gemini spacecraft?

Strong:

For the Gemini spacecraft.

Nebeker:

How did that work?

Strong:

It was a very unique device. In that era it wasn't clear how difficult it was going to be to make a rendezvous in space. So the Rendezvous Radar was to get them from the last two or three hundred miles down to a few feet.

Nebeker:

What rendezvous was being planned?

Strong:

Well, it was in preparation for going to the moon or for possible intelligence operations or whatever they chose to man in space. But the objective on Gemini was to rendezvous with a spent Agena missile as an experiment and to prove a technique.

Nebeker:

I see it was an experiment to see if you can do this.

Strong:

To prove that what you do.

Nebeker:

This hadn't been done before: a space rendezvous?

Strong:

It had never been done before and they weren't really too sure how difficult it was going to be. It turned out to be easier than they thought but the radar itself was an L-band radar. A very unique design with used spiral antennas that were flattened into a flat plate. So the antennas had the wide field of view. This was so you didn't have to point. But it used an interferometer principle. You could rotate the antennas and make the face angle look like it was going up and back. That allowed us to use it as an interferometer and measure the azimuth, elevation and, of course, we could measure range and range rate.

Nebeker:

Without mechanical motion?

Strong:

Well, it had mechanical motion but it was only rotational. And, so it made a very nice lightweight radar.

Nebeker:

Were you involved in the design?

Strong:

Yes. I managed the test program.

Nebeker:

It worked?

Strong:

Yes, it worked good. We learned a few things. I guess the biggest lesson there was something we later learned was called multipactor. In a high vacuum you would expect that you have good insulation and that you wouldn't have to worry about arcs and coronas and that sort of thing, but that's not true. At RF frequencies, if you have two metal surfaces at the right distance from each other, they'll set up a path and a few electrons that happen to be there will start to bang back and forth and knock a few more electrons loose which eventually ends up in a corona and an arc. We had some difficulties. The radar itself was pressurized so we didn't have to worry about it. Although I do recall seeing a little bit of corona on the end, on the antennae.

Nebeker:

Of course this is a new realm of engineering at the time. Working in space.

Strong:

Right. Later on, it turned out a lot of the Ranger satellites that explored the moon had this problem and nobody knew it. It wasn't recognized until looking back at the data later.

Nebeker:

Was it on Gemini that it was first really recognized?

Strong:

No, in that era, I think it was showing up all over the place where you had to have some kind of a transmitter. L-band seemed to be a good frequency for it because the distances are probably at much lower frequencies as noticeable. It was kind of an interesting, but anyway, the Gemini radar did its function. It worked well. It got us involved in the space arena. The other aspect of that era was that we really didn't know much about how to make things reliable. So you ended up doing everything. And, you know, we made some fundamental mistakes there. For instance, in that era, we were introducing worst-case design analysis. If you do a worst-case design analysis on most circuits, you'll find out they'll never work. For instance, somebody decided we shouldn't be using Alan Bradley resistors. They are little chunks of carbon. Not much goes wrong with them if you don't overheat them too much. But they drift all over with age, and temperature. So we used these new fancy resistors that were in a little tube that had scratched carbon. They were supposedly so much better and more stable. They held their values better. But the only trouble was the end caps came off under thermal stress.

Nebeker:

I can imagine that, in the 60s, with the space race, and the very rapid development of this technology, it must been a real challenge to get this stuff to work in space.

Strong:

We learned an awful lot about how to select good components and burn them in and so on. One kind of surprise I ran into was not on Gemini. It was one of the later programs. It was out at one of our suppliers that would screen parts for us and there were some very common looking plastic transistors being screened to the same reliability standards as our space parts. Whose parts were those? They were for Atari. You know, when momma gave this little electronic toy to the kids at Christmas they wanted them to work when they opened them. They learned to screen their parts just as well as in space.

Nebeker:

So, you worked on Gemini for quite a few years.

Strong:

Yes, it was about four or five years.

Working on the Advanced Technology Satellite Program

Strong:

And then I had a job called the electronics measurement experiment. It was for the ATS satellite program.

Nebeker:

What is that, ATS?

Strong:

The ATS was the Advanced Technology Satellite. It was to explore what could be done from a synchronous orbit. It was the first satellite to get an image of the earth from synchronous orbit. But its primary function was as a prototype for much of the communication satellites that followed. Our job was to work with universities who wanted to fly experiments to explore the Van Allen belts. It was felt that the universities were not well equipped to make and test the experiments and get them flight-worthy. So, we helped them build the experiment and then took the experiments and then put them into a package and provided the power and the environment, the temperature controls. We then put them through the environmental testing that was required and they flew on the satellite.

Nebeker:

Was this funded by the NSF or NASA?

Strong:

It was a NASA program.

Nebeker:

Teams of universities would apply to get on this satellite?

Strong:

Right.

Nebeker:

And if they were accepted, Westinghouse people would work with them to be sure that the equipment would work.

Strong:

Exactly.

Nebeker:

Did you find that interesting?

Strong:

It was fun and we got to meet a lot of scientists that we wouldn't have met otherwise, and it made me sensitized to some of the physics of space that I have found kind of interesting since I've retired.

Nebeker:

Well, it sounds like you had the perfect background for that job. To get them to make the equipment robust enough.

Strong:

Yes, it worked out well. We'd do the interference measurements.

The B-57G Bomber

Strong:

Probably the most fun job at Westinghouse was B-57G.

Nebeker:

Tell me about that.

Strong:

Westinghouse became the prime contractor to modify fifteen B-57Gs for the Interdiction Mission in Laos, to try to stop traffic on the Ho Chi Minh trail.

Nebeker:

This was a bomber?

Strong:

This was a bomber airplane. The airplane was a B-57, known as a Canberra in England, but which was then manufactured by Martin. So we subcontracted to Martin for a complete overhaul of the airplanes. It was called an IRAN process, where you take an airplane and go through it and inspect and repair as necessary. We then installed a low light level TV, forward looking infrared for night sensing, a laser designator which was originally to measure range, but later on became useful as a spotter for smart bombs.

Nebeker:

That was pretty early for laser applications, wasn't it?

Strong:

It was fairly early. The B-57 had a radar with an MTI function and the radar was provided by TI. It had a decent stable platform, you know for inertial guidance and inertial navigation and an automatic bombing process all controlled with that day’s digital computer.

Nebeker:

So, the bombing computer took the input from these different sensors?

Strong:

Right. So in principal an operator in the rear seat could fly up the Ho Chi Minh trail, see a truck in a radar maybe fifteen miles away, watch it until it got to three or four miles away. Then he could see it in the optical sensors. And the cross hairs and the scope would latch on to it. It would lock on to the spot. And track it in and to the IP and then it would automatically drop the bomb. As far as I know, it was the first digitally controlled system. Completely digitally controlled.

Nebeker:

I know that the early bombing computers were analog devices built in World War II. So, they continued to have analog technology and that kind of thing through the 50s and in the late 60s that you are working on this.

Strong:

Right.

Nebeker:

Did Westinghouse build the computer for doing that?

Strong:

Yes, Westinghouse built the computer. I think it had an 8K magnetic core memory. And I think they had to add another 8K before it was over with. It was all programmed in machine language and in the first week we flew, we found fourteen ways to make it freeze and bomb out on us with overflows or big problems.

Nebeker:

So, you were test manager for that project?

Strong:

Yes, and that involved both testing the electronics equipment and also the airplane.

Nebeker:

Because there were serious changes aerodynamically?

Strong:

The B-57 airplane had a real small tail and the engines were fairly far outward. So one of the difficulties with the airplane was a parameter called minimum single engine performance. If you lost an engine and were on a landing approach, at what point could you put on the power and still climb out? The airplane apparently felt pretty stable to the pilots and they thought if they were missing the runway they could climb out if they applied enough power. In this airplane, the tail was small, so they could not balance the asymmetry causing the tail to try to go around the nose. The airplane would stall and crash. This as an important parameter and it had to be recertified.

Nebeker:

Because you were putting on radomes and other things.

Strong:

Right. It had a big chin on it to handle the electric optical – the EO. The left hand side was two big plate glass windows for the TV camera to look out of, and on the right hand side were two great big plates of a pure germanium crystal that is used for the window for the IR. And so that had a big jowl that they were worried aerodynamically screwing up the airplane.

Nebeker:

So initially there were a lot of problems with the system.

Strong:

It never was a real neat system to maintain. I followed the airplane through category 1 and 2 testing, which we were responsible for, and then Category 3 which the Air Force did. Then they trained at MacDill Air Force Base, and I spent a lot of time down there helping keep the airplanes up to get the training function done.

Nebeker:

How much of it was Westinghouse?

Strong:

We were prime.

Nebeker:

So you were the prime contractor.

Strong:

We built the TV camera, the laser, the computer, and did all the software. The stable platform was basically standard equipment; the radar was a TI radar which had some unique problems. Then, of course Martin did the airframe and installed all the standard electronics. And, it had new bottom doors for it.

Nebeker:

How was it as a test engineer dealing with different parts of the system? I mean if it's Westinghouse, does that make it easier to resolve things than if it's TI?

Strong:

Yes. We had some conflicts. TI had their radar manager spend most of his time here over a period of about a year: six or eight months during testing. The radar had a problem. The moving target, the AMTI function, gave banding on the scope and they couldn't see much of anything. TI went back and redesigned the antenna a couple of times and it was not until actually Category 2 testing was almost over that the Air Force said okay, send the team out. We were not really permitted to do much on the radar because TI was claiming the design features were proprietary. Finally the Air Force asked some of our analytical types to go out and take a look. They found that the problem was a leaky diode that would cost about twenty-five cents to fix. You know, in that era, how electronics specifications required that equipment be modular? They liked to take the antenna, and the processor and you should be able to take any of those boxes, put any combination together so they can work with no additional adjustments. And TI took that to an extreme and it had the antenna designed here, the processor designed here, the receiver design here. And, it turned out they were losing about 30 db in gain and didn't realize it because the boxes were never, integrated, in a sense.

Nebeker:

So, were those planes flown and put to use?

Strong:

Yes. In fact, I spent thirty days in Thailand. They took twelve airplanes to Ubon, Thailand and flew the Ho Chi Minh trail. It wasn't too effective. Maintenance problems were high. The second year they used them secretly down in Cambodia. I don’t know too much about that. I left the program before then and was no longer privy to what was going on. The airplanes were taken out after the second year and were given to the Kansas National Guard. The cost of maintenance was too high for them. So they ended up being scrapped.

Working on Meteorological Sensors

Nebeker:

So, I see your next major project was a meteorological sensor.

Strong:

Yes. Next, I got moved down to the DMSP, which we called the Block 5.

Nebeker:

What does that stand for?

Strong:

It stood for nothing. On that program, we were subcontractor A and Kollsman was subcontractor C. It was an attempt to make sure that nobody on the outside knew who all the contractors were. Block 5 was a code word for the sensor. It was to support the Corona intelligence system. Corona was a satellite that the Air Force was flying, taking pictures over Russia with a big camera. And they would dump the film near the Hawaiian islands and pick it up with a trapeze arm on a C-130 and send it to Washington to be processed. They didn’t want to take pictures of cloud cover, so the satellite's primary function originally was to give worldwide weather pictures so that the intelligence people would do their work when the clouds weren’t blocking their view. We have the original sensors out in the display case out there.

Nebeker:

Were these optical sensors?

Strong:

They were optical. They worked visible and infrared. And they got full world coverage in about 0.3 of a mile resolution of infrared and visual. The visual gave you nice details and the infrared showed you how high the clouds were, by their temperature – they get colder as they get higher. We were also able to derive wind directions and velocities and some other sensors were flown too to help them.

Nebeker:

Was that data made use of for general meteorological purposes?

Strong:

Yes, it was used for all Air Force activities. And they provided the data throughout. It had a capability to downlink local data, if you could catch it during its pass.

Nebeker:

I see.

Strong:

I remember one case where a colonel in Germany was very adamant that, after the satellite passed over the Desert Storm region, that it should come back to Germany and dump the data so he could get his data first, not realizing that satellites orbit, rather than fly by commands. They put a display on one of the aircraft carriers as an experiment about the time I was working on it, so the Navy would get real time dumps. I remember after the six month sea trial, somebody asked if they could get the equipment back off and the skipper said they could do it if they could get it past his Marine guards. The normal downloaded data was all processed in Omaha at the Air Force Weather Center. To this day they produce data that's updated every four hours or so, essentially worldwide.

Nebeker:

And you were program manager for that sensor?

Strong:

I was a program manager for a new version, which we defined as the OLS. Very interesting device. In fact, one of the telescopes is in our case out there. It's an 8-inch Casgrain telescope, and it’s suspended with four stainless steel springs. It works like an electric clock where it swings back and forth and you hit it with a little bit of energy as it passes through each time so it will maintain exactly the right swing. There is an optical device at the end to control how far it swung. The telescope swings back and forth at six times per second. And each movement takes one three-tenths of a mile swath of the earth. Each of the swaths are continuously added together to make a map.

Nebeker:

So, it’s moving in order to do what, exactly?

Strong:

To do the lateral scan — the azimuth scan. Satellite velocity, provides the forward scan, so it's a line scanner. Somebody came up with the name “Operational Line Scanner" to try to get operational into the name of the device although at the time we didn’t have the foggiest notion whether it was going to work or not. The concept was developed by two really bright Westinghouse people. One was Frank Rushing, who was a mechanical engineer and one of the greatest as far as I’m concerned. The ladies will all appreciate him because he’s a guy that developed a process that keeps their washing machines from going out of balance. And Gordon Ly, who was an excellent engineer in electro-optics. It was really remarkable that such a thing would play. You take these four springs: we went through many, many, many materials. It was almost like an Edison-like process. Making springs in different tempering. We finally found something that seemed to work and it did work. They’ve last as long as fourteen years in orbit. And there are still two of the satellites left.

Nebeker:

You said they’re swinging six times a second.

Strong:

Six times a second.

Nebeker:

It's pretty impressive that a spring could hold up.

Strong:

It is impressive to see. Of course, it’s in a vacuum. Anyway, that was an interesting chore. I moved on into a couple of proposals before it was really into production and then the gentleman who had negotiated a contract with Jet Propulsion Labs for us to build the transmitter and Pulse forming circuitry for the Seasat became ill, and so I moved onto the Seasat job to fill his shoes.

Nebeker:

Is that a navigation satellite?

The Seasat

Strong:

No, Seasat was a synthetic aperture radar for studying the oceans.

Nebeker:

I see.

Strong:

So it was a Jet Propulsion Laboratory project. It was very successful for about thirty days. And then the slip rings on the satellite failed so it lost power. But there’s a lot of good imagery available from that. They were studying ocean phenomena. One of the things that came out of it: the synthetic aperture radar was part of it but they also had a very accurate radar altimeter, and that process has been used by Navy since then on the Poseidon and others to map the bottom of the ocean.

Nebeker:

This altimeter is actually detecting the bottom of the ocean?

Strong:

No, not directly.

Nebeker:

It’s measuring the surface.

Strong:

It measures to altitude to the surface of the ocean. And they claim to make it down to a fraction of a centimeter. Now the height of the satellite is directly proportional to the gravitational constant at that point in space, and that in turn is dependent on how deep the ocean is because the density of the water is different than the rocks below it.

Nebeker:

Rock is much denser of course.

Strong:

So, by plotting the altitude to a very minimal altitude difference, they can basically make a map of the bottom of the ocean. So, now a process that takes years and years to do with a ship, they were able to do in weeks.

Nebeker:

What was your role on the Seasat?

Strong:

I was program manager for the design and production. And we basically made two transmitters. They had the pulse-forming transmitter – it had a chirp transmitter pulse – and a solid state transmitter. We had basically three five-hundred watt L-band amplifiers that combined to make the thousand watt pulse. It also had an optical delay line – or an acoustic delay line – that formed the chirp pulse. We developed that with the help of another subcontractor. And it flew as the Seasat A. The Seasat failed after about thirty days and then we took the spare parts that were left over and built the radar again and reoptimized it for looking at land. And it flew twice as the SIR A and the SIR B, the shuttle imaging radar A and the shuttle imaging radar B.

Nebeker:

I could imagine that must have been sad for all of you involved when it failed after the thirty days or so.

Strong:

Yes, there are a lot of rumors going around on that failure and I have a JPL friend who swears he saw data that was taken later. So, there have always been rumors hanging around that it was actually shut down because it was working too good.

Nebeker:

Maybe some other agency wanted the data that was coming out.

Strong:

Right. But I think it failed.

Nebeker:

I can just imagine when one has put so much work into it.

Strong:

Well, there were rumors that it was seeing wakes where there were no ships.

Nebeker:

So what did you go to after the Seasat?

Late Career and Retirement

Strong:

After the Seasat, I started working on a black program. I spent several years on that. And then I finished up doing some studies. The last interesting project was a study for doing a tactical radar from space, and we essentially developed the guidelines for a system of ten satellites at fifteen hundred miles that would detect essentially all the aircraft traffic on earth as its moving. It was too expensive to ever build but it was interesting to work on. I retired in 1991, so it’s been quite a few years. I spent thirteen years working one day a week at the Smithsonian in the archives.

Nebeker:

Oh, nice. What museum?

Strong:

Smithsonian Air and Space. We answered letters and we did the research for answers to letters. But, I spent some time here at the museum.

Nebeker:

Tell us about your involvement with this museum.

Strong:

I had been volunteering over at the airport, at the information desk, and that disappeared, so I came to the museum looking for something to do and before I knew it I was on the Board of Directors. Then they asked if I would be Chairman of the Board.

Nebeker:

What years were these?

Strong:

Oh, let's see. We’re going back about ten years. And I’ve tried to design some of the exhibits there in the space gallery. I've helped out in the radar gallery here and there. So the museum itself is, I think, a real treasure. I’ve done quite a bit of work on the archives here. I'm currently still working on labeling pictures. The museum has thousands of pictures from Westinghouse, Northrup Grumman and elsewhere.

Nebeker:

So, you’ve kept busy in your retirement years?

Strong:

Very busy. I’ve since moved over to Charlestown, which is a retirement community, where I’m living now. I’ve got involved too deeply in a Lifelong Learning program over there. We've a small community and then all of a sudden we have eighty courses offered. We filled four thousand seats this year. This community is about two thousand people. So, that’s been keeping me busy.

Reflections on Career

Nebeker:

Wonderful. Is there anything I didn’t ask about that you care to add on?

Strong:

I think we pretty well covered a lot of the waterfront. I didn’t do any papers or anything. I’ve been kind of in a process of clean up after a lot of projects and almost the last engineer off of BOMARC and last one off of some of the others.

Nebeker:

You’ve been involved in a very important way with a lot of exciting systems over the years.

Strong:

I’ve been exposed to a lot of programs. Much more so than some that have stayed in a fairly limited area. Of course, I’ve learned enough about everything to be dangerous, instead of with any of depth. But you know, you start to appreciate how the equations the mechanicals used are the same as the ones the electricals use. The great use of the spectrum we’re making and so on.

Nebeker:

Well, thank you very much.