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The questions in this transcript were asked during an oral history session with Stefan A. Cavallo. Mr. Cavallo has amended the answers for clarification purposes. As a result, this transcript does not exactly match the audio recording.

JOHNSON: Today is September 30th, 2005. This oral history session is being conducted with Steve Cavallo from New York, New York, formerly working with the Langley Research Center [Hampton, Virginia], as part of the NACA [National Advisory Committee for Aeronautics] Oral History Project sponsored by the NASA [National Aeronautics and Space Administration] Headquarters History Office. The interview is being held in San Jose, California, during the NACA Reunion XI. The interviewer is Sandra Johnson.

I want to thank you again for taking your time to meet with us today. I'd like to begin today by asking you how you began working with the NACA, the National Advisory Committee for Aeronautics.

CAVALLO: Sometime just before December 7th, 1942, about October or November of 1942, the NACA solicited the senior class of Engineers of NYU [New York University, New York], that they were accepting interviews for the job of Aeronautical Engineer at their Langley [Aeronautical] Laboratory at Hampton, Virginia, so I applied for the job. It was fortuitous timing, for I had applied for the job before the start of the war, which made me eligible for consideration. At that time, I was at the New York University Guggenheim School of Engineering and I was majoring in aeronautical engineering. At the same time I was also taking

a Civilian Pilot Training Program [CPTP]. The CPTP was made available to all the students, but especially to aeronautical engineers. I was also an officer, a cadet officer, in the ROTC [Reserve Officers Training Corps].

When the war started, I was in a class that was scheduled to graduate in June 1942 but was accelerated to April 1942. At the time of my graduation, I presumed I would be indoctrinated in to the Air Force because I was graduating into a war as an Officer in the cadet corps and due to be sworn in as a Second Lieutenant in the Army Air Corps, as it was called in those days. However, I got a notice from NACA at Langley that if I wanted to, I could report for duty with the lab. The notice came on a Wednesday and stated that I was to report on the following Monday. Being that the call was unexpected and the time allowed so short, I thought it was unusual, I called Langley for verification and said, “Can I do this?"

They said, “Yes, sure.”

I said, “But I’m supposed to be an officer in the Army Air Corps.”

They said, “We have priority.”

When I told that to the ROTC Colonel, he said, “If you report to Langley Field, I’ll have you arrested.” He further said, “You belong to the Air Corps. You spent four years in ROTC. We are swearing you in Saturday.”

So I called Langley to reconfirm their offer. I said, “Can you put it in writing? The Colonel said he is going to arrest me if I report to Langley Field.”

They said, “Well, we have priority. But it is your choice.” And they sent me a telegram saying to report to Langley the following Monday.

With great trepidation, I got into my model A Ford and drove for two days to get to Langley Field, Virginia. I reported to an administrative officer by the name of Elton Miller.

After a cursory interview, he assigned me to the full scale tunnel. I said to him, "But, I have a pilot's license and I am interested in the flight aspects of engineering."

So he changed the assignment and said, "Okay, I'll put you I the Flight Section," as it was called in those days.

And so, I was assigned to the Flight Section as an engineer—not as a pilot. The rating was as a P-1 Aeronautical Engineer paying $2000 a year, with an automatic $18.75 deduction every other paycheck for a $25 war bond and fifty cents for income tax. I kept these bonds for their full life of paying interest and the amount I received was very significant.

For six months I worked reading manometer film. The data that the pilots had collected on their test flight runs would be registered on film in a manometer. The engineers and the "computers" would read the deflections caused by sensors through a microscope. The computers were ladies who had a college degree in math and assisted the engineer in charge of the project in reading and working up the data.

When I'd been doing that for about six months, I heard that a couple of the pilots had left for one reason or another. In those days all the pilots at Langley were civilians. However, some of them had been in the military or had military training before coming to Langley as pilots. Herbert H. Hoover had flown bombers in the Army Air Corps in the 1930s and Melvin N. Gough, who was the chief test pilot at that time, had gotten his training in the Naval Reserve.

I approached Mel Gough and asked him, "Is there a possibility that I could fly with the Flight Section?" as it was called. I told him of my credentials, and much to my delight and amazement, he accepted me as a pilot, and I was assigned to the Pilots Office. It was as simple as that in those days. Today you would have to have a doctorate in physics and be an Air Force

Academy graduate. But the war was on, they needed pilots, and I was available with an aeronautical engineering degree and couple of hundred hours of flying time.

JOHNSON: Where had you learned to fly?

CAVALLO: The Civilian Pilot Training Program, which I mentioned before, was held at Teterboro Airfield in New Jersey in 1940 and 1941. After school and on Saturdays or Sundays and whenever I could, I would get into my Model A Ford and commute to New Jersey. The George Washington Bridge was fifty cents each way and the ferry was a quarter. The flight program was divided into two parts, called the Primary and Secondary Course. In the Primary Course instructions were given in a sixty-five horsepower two-seat Aeronca Champ. All the flight training and tests leading up to a final check-out and a private pilot's license were given. Generally that would take about six months, after which one was eligible for and could take the Secondary Course. The Secondary Course consisted mainly of acrobatics and was flown using Waco UPF-7 airplanes. They were open cockpit, fabric covered biplanes, with a 450 horsepower engine. They were very similar in appearance and performance to a World War I fighter. The instructor sat in the front and the student in the seat behind him and all signals were given by hand. The methods seem crude by today's standards but it was all hands-on flying with an extensive program of aerobatics. We did maneuvers that they don't teach, and can't do in today's, aircraft. There was no avionics and no electronics in this airplane. It was all basic flying and but we all learned to fly pretty well.

By the time I graduated from NYU, I had the credentials of a pilot's license. Not that I knew what to do with it at that time, but fortunately it fit into the NACA requirements for an

engineering test pilot. So that's how I got into flying at Langley. Today it seems almost that it was magical. It was wonderful! It was probably the best years of my life, certainly in terms of technical achievement and in satisfaction in what I was doing.

However, when I reported for duty in the pilot's office, Herb Hoover had become the chief pilot and had taken over the training of engineers to be pilots. This concept had been created by Mel and turned over to Herb when Mel became Division Chief. Herb was an excellent pilot, dedicated and courageous. He was patient and very fair with me. But, this was a program that he had inherited. I remember his admonishment to me on the first day that, "I'm not running a flying school." Mel Gough had trained two other engineers and supervised their transition into test pilots. Mel was the designer and prime mover of the program which was based on the premise that it is easier to make a test pilot out of an engineer than it is to make an engineer out of a test pilot.

Jack Reeder and Bill Gray, the previous two "converts," and all of us had civilian pilot training, but we had not served in the military and did not have any military flight training. So, with a background of having worked as an engineer in the Flight Section, as well as being shown "tricks of the trade" by Mel and Herb, I was eased into test flying. It went very well and it came very easy. I was able to contribute and make what I felt was significant progress to the point where I was doing the work that was required.

The programs at Langely, in those days, were much diversified. We had everything to test, from very simple airplanes such as the XR2K-1 which was a high wing monoplane, to large amphibians such as the PBY-5A as well as the P-80 jet powered fighter. The monoplane allowed us to attach various shaped wing forms and ran through a series of stability and control tests. This airplane could not go over 130 miles an hour which would simulate large scale tunnel

results but under actual flight conditions. Stick forces at various roll rates were measured by using a unique device. It was a hand-held instrument that fit between the pilots hand and the stick. It had a small dial with numbers indicating the pressure being applied. These measurements were read by the pilot and copied by hand onto his knee pad.

In those days NACA was very busy with designing wing shapes of different cord lengths and a variety of upper surface camber. These flights required the simplest type of flying. However, I can remember flying in the open cockpit of the XR2K-1 in the winter time. I would put on all the winter flying clothes I could, including a face mask. However, I could not keep flying for more than twenty to thirty minutes on those cold winter days.

Our biggest range of types of airplanes was in the fighters. For test purpose, the Air Corps sent us the Brewster XSBA Buffalo, Curtiss P-36, the Bell P-39, Curtiss P-40, Curtiss P-42 (P-40 with a radial engine), Republic P-47D and N models, North American P-51A, B, D, and H, Bell P-59 (swept wings), Bell P-63, and the P-80. The Air Corps also sent us the Boeing B-17, Consolidated B-24, Douglas C-47, Boeing B-29, Douglas R4D, and the YR4B Sikorsky helicopter. The Navy sent us, and we tested, the North American SNJ, Consolidated PBY Amphibian, Grumman F6F, Curtiss SB2C, the Grumman JRF Amphibian, Curtis SC-1, and Douglas SBD. There was also a large selection of civilian aircraft, which we flew, including airplanes from Lockheed, Fairchild, Piper, Beech and Culver. These are not all the planes that came through our flight section while I was at Langley but they are the ones that I got from referring to my log book.

Most of our work on these planes was in determining and then improving the stability and control of the handling qualities of these planes. We had a brilliant engineer in Robert R. Gilruth and we had a marvelous engineering test pilot in Melvin N. Gough. Together they

created the bible of stability and control. The handling qualities of all future airplanes would be based on the parameters they outlined. Up to that time a pilot would fly an airplane, and the attitude was, "Well, if you go back and fly it the second time, it must be a good airplane." Or the pilot would be asked, "What is it that you like about the plane?" And those early-time pioneer pilots would try to describe what it was they liked about the airplane. Whether the stick forces seemed too heavy or if the plane didn't roll fast enough, etc. It was all kind of subjective stuff based on pilots' opinions.

Then Mel and Bob decided, "Let's quantify this. Let's put some numbers to these opinions." What is it that a pilot likes in a fighter as well as in all other categories of planes? What does the pilot want to feel? What response is he looking for? How much G [gravitational] force does he want to pull? How much can he handle in a roll? When does he get uncomfortable or reach his limit of physical response. Is any of this different in a fighter or a bomber? Does he expect the same stick forces and rudder forces in a fighter as he does in a bomber?

So all of that became a matter of negotiation, and between the two of them, the pilot and the engineer, they quantified the parameters. They wrote what I call a bible of stability and control and described what ideal handling qualities are in any type of aircraft. It was no longer up to the designer and manufacturer to produce and present a product that was satisfactory to their designers and test pilots. It was a mandate to meet the requirements outlined by NACA. In those cases where the plane did not meet the parameters outlined, the Lab would take on the problem and correct it.

For example, we increased the roll rate of the P-51 by installing cusped ailerons. As time went on, very exotic testing and measuring equipment began to be developed. From a crude handheld pressure-measuring device, to where all the instrumentation was installed in the wings

or fuselage. These were activated by the pilot at the start of each test run. The basic recording device was a manometer which put trails and blips of light onto a wide film. These light deflections were activated by sensors installed anywhere on the plane where measurements were required. Some could measure deflection, some could measure force, and others could measure angles. The film was developed and the deflections were read through a microscope by the engineers and computers. A lot of flight test work was required and accomplished at Langley in the war years. The airplanes varied from Cubs to B-29s and included helicopters and multi-engine amphibians. All of these planes came to us with a flight problem that needed fixing.

We also had the responsibility of transporting people who needed to go to our office in Washington D.C., which was located at DuPont Circle in those days. We also had a rocket testing facility at Wallops Island, Virginia that required transportation service. To get to Wallops, we needed to fly a Grumman Goose Amphibian into a creek. The creek was a body of water about 50 meters wide and 2500 meters long which ran parallel to the ocean and was about 150 meters from it. The sand strip between was where the testing facility was located.

I was checked out to fly into the creek and it became pretty much my specialty. I got very proficient at landing and taking off into that small area, in all kinds of wind and current conditions. At first we would "make buoy." This involved taxiing up to and hooking on to a buoy anchored in the creek. Someone from the land base crew would come out in a boat to meet us.

The plane could carry the two-man crew, eight people and a considerable amount of baggage. The seaman would then "scull" a flat-bottom, rectangular boat from shore. The boat had a cut-out in the center backboard into which an oar was place and "fanned" back and forth, like a fishtail. The boatman would stand up and face forward while everyone else sat down. It

was easier for these men to scull than it was to row and I've seen them do it in all kinds of wind, wave and current conditions. Later on, a metal ramp was installed on the shore and I was able to put the gear down and taxi up onto shore to discharge personnel and equipment. Most of the people and equipment were concerned with rocket research. But the rocket launching that I viewed was for the most part very disappointing. The rockets would go up these long seaward pointing ramps and often end up in the ocean. I saw some that never got out of view. And this was the time the Germans had their V-1s and V-2s hitting London. It was a sad commentary on our viability in rocketry. America was fortunate to be out of range of enemy weapons.

There was a big Quonset hut on the island where everyone would have lunch. It had big sign over the front door with the name "Club 75." The cook had learned his trade in the army and the main course was always roast beef with potatoes and vegetables. The cook fascinated me as he could make the best gravy for the roast beef out of vanilla extract, mustard, ketchup, onions, flour and other condiments. It had the color and taste of the real thing. There might have been other things on the menu but I don't recall what they were. It cost 75 cents to have lunch and hence the Club 75 on the sign over the entrance. To me, 75 cents was a lot of money for lunch, so I generally brown-bagged my lunch, as many others did.

We got a check twice a month and they would take out a mandatory $18.75 for a war bond and 50 cents for income tax. I had a wife and child by 1944, so of course we operated on a limited diet and a budget. There was enough for civilians to eat of course, but the selection in the food store was limited, especially with meat.

As I said, we operated a large variety of military aircraft. The largest was the B-29, which I flew as a co-pilot with Bill Gray at Pilot-in-Command. We flew long missions, generally over Wallops Island where would drop various bomb-shaped vehicles to test their drag

and velocity. We often brought the B-29 back with one engine feathered as the Curtiss Wright #3350s had a reputation for overheating and failing. However, we were lightly loaded and close to home. I used to wonder what the air force did in the Pacific on those long over water flights with a full load of fuel and bombs.

Most of my flight test work was in fighters and addressing whatever problems that they were having. However, in one area, I flew the P-51 when it was being used as a test bed for scale model testing of current and future airplane designs. In this program we had modified a P-51 by adding a "cuff" around the main wing. This was actually an airfoil overlay which had been carefully polished and buffed to almost mirror smoothness. Under this part of the wing and in the gun camera compartment, a miniature wind tunnel balancing device was installed with a measuring rod sticking up and protruding through the cuff. On this rod was attached a very accurately made one-half shape of a plane under study. The X-1 and many futuristic planes were tested that way. The rod would rotate the model through various angles of attack and readings would be taken on the lift, drag, angle of attack and pitching moments and transmitted, through the rod, to the mechanism in the wing. This data was collected by the manometers in the wing and traced by light deflections on the film.

The technique involved was to take the P-5l to about 32,000 feet, level off to get stabilized and turn on the instruments. This would start the model on the wing, turning through various angles of attack. The P-51 would be pushed over into a dive of about 45 degrees which would continue to accelerate to Mach No. 0.73. At about 10,000 feet, a recovery or pull-out was started. This generally would produce anywhere from 2 – 4 Gs. The idea was to dive through as smooth air as possible. Flying through rough or gusty air would superimpose extraneous forces and conditions upon the flight data being collected. This would make the work-up and analyzing

of the data very difficult. The engineers and the computers were pretty skilled and no matter what you gave them, they could correct for any "pollution" and sort it out. However as the expression goes, "garbage in is garbage out." And I had been on their side of the program when I was the one reading the data, so I was very sensitive to the problem of the film readers.

On the climb up to altitude, I would look for areas of clear air. And in the dive, if I encountered rough air, I would go back and repeat the dive, as long as I had film left. This conscientiousness was one of the results of a pre-flight training period in the engineering office.

I would start my pull-out at about 10,000 feet. The idea was to be out of the dive by 5000 feet. In the course of pulling out from the dive, a G force of between three to four Gs was experienced. If the dive continued past 10,000 or a patch of rough air was encountered in the pullout, the G forces could go as high as 4 to 6 Gs. At this point the pilot would black-out for a period of time as the plane came around to level flight. We did not have G suits in those days for these flights. There was one case where one of our other pilots did run into a condition which required a 6 G pull out. He blacked out and came to climbing back through 10,000 feet. In a pullout, the pilot was in an area of significant risk in these dives. We were always dealing with the negative effects that compressibility could cause. This was the tendency of the plane, once in a dive, to increase its dive angle and speed. If the speed built up was allowed to continue it could lead to destruction. Fortunately the only casualty I suffered from these pull-outs was from hemorrhoids.

At the thickest part of the wing, where the model was mounted, the highest velocity of air flow occurred. If the airplane in the dive was at Mach .73, the airflow over the wing where the model was located was at Mach 1.2. In essence this provided data through the speed of sound at

a time when the high speed tunnels could not provide it. The models of all of the oncoming fighters and the X-1 were tested that way.

When the airflow over the wing exceeds the speed of sound, a shock wave occurs. At the same time a shock wave occurs on the wing, where the velocity of the air exceeded Mach 1 or the speed of sound, a shock wave also occurs on the horizontal tail at the hinge line between the stabilizer and elevator. This shock wave weakens the effectiveness of the elevator, which is operating behind the shock wave and is blanketed by it. The wing has a natural pitching moment, or tendency to dive, with an increase in speed. This would require additional up-elevator or an increasing pull force to trim for a steady dive. Eventually the pilot would reach a physical limit to his ability to hold this pull force. Either a pullout had to be started before this point or the plane would continue into a catastrophic dive. Many P-47 and P-38 pilots in combat would get into a diving condition and reach their physical limit to recover. These two airplanes were noted for this catastrophic tendency. Because we were doing these dives on a daily basis, we were aware of this problem, called the "compressibility effect." Use of the trim tab to reduce the pull force as the speed increased would have to be done judiciously. The pilot would be pulling increasing forces as the speed of the dive increased. The elevator was losing its effectiveness. The pilot would try to compensate by pulling to get more up-elevator. He'd crank in trim tab to help him with the pull force. At some point he would decide he had reached the limit of his ability to handle the pull forces and would start his recovery. The airplane would slow down and start to recover. As the air over the tail surface went subsonic and the shock wave disappeared on the hinge line, the elevator suddenly became effective again. The elevator forces, helped by the up-trim tab, suddenly became light. The pilot who had been pulling to his

limit now finds himself with the stick "in-his-lap." This condition will provide excessive G forces on the wings.

A memorable P-51 flight occurred when we did studies on the effect of gust loads at high Mach numbers. As least that was the understanding I had as the bases for the study. I had also heard that there was an interest in this project because we were losing P-51s who were escorting the B-17s on their way back from Germany. The pilots and planes were lost over enemy territory and consequently there was no empirical data on the cause of these losses. Typically, these losses were occurring when the group would be flying through cumulonimbus clouds, in the evening, when the clouds couldn't be seen or avoided. The B-17s would transit these summer storm clouds and experience high buffeting, often accompanied by a significant change in altitude. The P-51s seemed to fare less favorable. Often one would be seen spinning out the bottom of the clouds with no attempt of recovery. It was assumed that the wings were failing. So we started a study on the effect of high gust loads on the P-51. I did a series of tests on one of the P-51s. By using very abrupt pull-ups at the normal cruise speed, I was able to get a reading of plus 12 and minus 4 Gs. These loads certainly exceeded the design parameters of the wings but these were loads achieved in rough air and were very short duration. These were called "gust loads." However, in one of the tests I tried to pull out abruptly while I was flying in rough air and I wrinkled the wings on one plane, but the wings did not fail. Hence, these tests did not produce a definitive answer as to why we were losing the P-51s in rough air.

In an accelerated or sudden pull-up in the P-51, the pilot would find it difficult to reach a G force sufficient to lose the wings. In a sudden pull-up, at any speed, the wing pitches up and the Gs build to a limiting condition. As the angle of attack and the G forces build up in this pilot induced pull-up, the wings would stall and the G force would be relieved. At least that was what

was thought. When I was assigned to do tests on accelerated stalls, I was told that in any pilot-induced sudden pull-up, the plane could not reach a condition where the Gs were excessive. Another pilot had preceded me and had recorded this effect. He did what he considered "abrupt" pull-ups and the wing had stalled at all dive speeds before destructive G forces were encountered.

I was given the task of continuing and completing these preliminary tests. On the first flight I pushed out into a fairly high speed dive and after starting the instruments, pulled the stick back as hard and fast as I could. I had been assured that this was okay. The wing was supposed to stall and buffet, but not fail. Apparently, I had pulled the stick back very much faster than the previous pilot and the wing rotated rapidly through the angle and region where it was supposed to stall. It pitched to a high angle of attack, at high speed, and accompanied by heavy buffeting, significantly exceeded its design limits. However, because the loads were of short duration, the skin on the wings became wrinkled, but the wings did not fail. My enthusiastic performance did not find favor in the office. But it did indicate what might happen in combat with a pilot under stress.

The Air Corps assigned us two high-time P-5ls, which had been used in a pilot training school. The fuselages had about 3000 hours of flight time on them. Probably the engines had less flight time. However, these planes were accepted for this test because we were going to fly them into high gust-load conditions and the planes would get beaten up more than they had been. Their high time made them unacceptable for combat. It was unusual for Mel and Herbie to accept such high time planes for test work as they had always insisted on first class equipment and maintenance. This was in keeping with the pilots and the mechanics that were all very dedicated and well-trained. We had an enviable safety record. In the five and one-half years I

was at Langley there were only two bail-outs. Bob Baker left a P-47 and I had to bail out of one of the P-51s.

These P-51B model that we got for this summer storm testing were unique. They had the "Messerschmitt" canopy. This canopy is flat on the top and follows the line of the upper fuselage. It had a very streamlined appearance. All subsequent P-5ls had a bubble canopy. The visibility was better, but the trade off was that it lost some of its top speed, and it was harder to bail out of because you were seated lower in it.

So, on one hot July day when there were plenty of billowing summer clouds around, Bob Baker and I went out in these two fighters. The concept of the test was to have one plane fly through the storm cloud at 18,000 feet and 185 mph. A second plane would stay outside of the test area and conditions and fly at the same altitude and airspeed. Both pilots would take records simultaneously. This would produce ambient air and actual rough air records to compare. This flight would simulate the conditions that the B-17 and P-5l group encountered on their return from Germany. Because I was in the lead, I found a suitable cloud and flew into it. I experienced instant and considerable roughness. The accelerometer on the instrument panel hit the limits of plus 12 and minus 4. But these loads were of short duration and similar to the loads I had experienced on the preliminary tests.

The flight continued through very rough air for some time. Suddenly, I noticed a hole appear in the cowling in front of me. It was about the diameter of a piston. Strangely, it didn't seem significant nor was there any effects for the moment. Then the oil pressure started to decrease and the RPMs [revolutions per minute] started to increase. There was a sharp jolt as the engine threw a propeller blade. A wave of yellow flame swept back over the top of the canopy. I had come out of the clouds at that point and Baker was alongside of me at about one mile

distance. Up to the time of the fire, I had thought I could land in a field. When the fire broke out, Baker radioed me to bail out. I jettisoned the canopy, took off my helmet and seat belt and started a roll to the right. I thought it would be easier to bail out if the plane was inverted and if I just fell out of it. I rolled the plane over and tried to stay out of a dive by holding the plane level. This caused the flames to go under the plane and away from me. And as the plane continued into the roll, I started to slide up the side of the cockpit while still holding onto the stick. As a result, I never got completely inverted before I started to slide out of the plane. I was hit in the face by the 180 mph air velocity and had to let go of the stick. I grabbed for my knees and went out between the vertical and horizontal tail surfaces. It was fortuitous that the plane was neither level nor at a ninety degree angle, because I wouldn't have passed between the tail surfaces as easily as I did. I can still see the vertical numbers on the tail as it went by.

It was obvious then, that it was not the wings that were failing in this gust load condition, it was the engine that was failing. This was something that no one had mentioned. The Packard-Merlin liquid-cooled engine which powered the P-51s was a long-shaped engine. It was attached to the fuselage by an engine mount that cantilevered it out front. Because of this, the engine was at the end of an arm that could "whip" it up and down in these gusts. While the wings had been designed to take gust loads, the engine piston rods were not. There were hundreds of P-51s flying in combat. It would be impossible to retrofit all those planes. The only rational conclusion was not to fly P-51s into storm clouds. However, I never saw this written in the P-51 manual or even mentioned again.

I think that this test was apropos of some flight testing techniques in those days. Especially, with a war going on! Practical solutions were needed as soon as possible. In some

cases, if there was no fix found quickly, the project was terminated. However there was always some basic research test going on.

The all-movable tail was one of them. Walter Williams was the engineer in charge of this project. It had been developed and tested with installation on the P-36 and P-47. It was this development and this type of tail configuration that permitted the X-1 to go through the speed of sound. It was an NACA invention. It had been developed and perfected by an NACA engineer who was in charge at the time of the X-1 flights. The Air Force claimed it was Captain Jack Ridley who was responsible for the installation of the all-movable tail. From an installation point-of-view, this may be true. However, the engineer who had designed, built, tested and suggested the use of the all-movable tail was Walt Williams. Walt was on the scene as the NACA chief engineer at the time the installation was made.

By the use of the all-movable tail, the shock wave was eliminated. As mentioned before, as the airflow over the tail went supersonic, a shock wave would "stand" at the hinge and elevator junction. The turbulence created would destroy the effectiveness of the airflow over the elevator. With the all-movable tail, the portion of the tail in front of the thickest part of the horizontal tail would be in a condition of smooth air flow and would be aerodynamically effective. And that is all that is needed for longitudinal control in supersonic flight.

Another example of the use of wartime quick-fix tactics concerned itself with a ditching problem the B-24 bombers were having. The B-24s were returning from raids in Europe in battle-damaged condition and were having difficulty making it all the way home. There were incidents of planes with one or two engines out, which were being ditched in the English Channel in the hope of the crew being picked up by the Royal Navy. However, there was a very

low survival rate of the personnel who didn't bail out, and had preferred to stay with the plane. It seemed that ditching a B-24 was always fatal. This was not the case with the B-17s.

I remembered the B-24s going through Langley on their way to Europe. They were crewed with flying officers who were usually Captains or First Lieutenants whose ages were always in the low twenties. The crew was even younger. Invariable, the crew would take advantage of the several hours lay-over and run into town to buy lumber. They would then reinforce the bomb bay section of the bomber. They had heard tales about the bad ditching characteristics of the B-24 and they wanted to reinforce the bottom of the plane before they left on the overseas flight to Europe.

We had a program assigned to us by the Army to address this problem and provide a solution. In November of 1944, the Air Corps assigned Major Julian Harvey to NACA. He was to be the pilot in command of flying this project. He had been flying bombers with the 8th Air Force since the start of the war. He had flown the B-17s and the B-24s in combat and he claimed to have successfully ditched a B-24 in the English channel. He claimed that the air crews were not fighting to get their planes back after they had been damaged by gun fire. They would often divert to friendly or neutral countries. They were reluctant to stretch a flight over the English Channel where they might be required to ditch. Consequently there was a shortage of crews and equipment in the 8th Air Force.

Harvey was a tall, blonde, handsome man who wore both the RCAF [Royal Canadian Air Force] and the United States Army Air Corps wings. Under each set of wings were rows of medals and campaign ribbons. He was an American who went to Canada before December 1941 and enlisted in the Canadian Air Force. He was flying for the RCAF when we entered the war, at which time and he was transferred to the American Air Corps.

He claimed to have ditched a B-24 successfully. Because of his wartime record in those early days, his good looks and his many decorations, he had a very egotistical air. He wore the special-cut Eisenhower jacket, pearl-pink chino trousers and a yellow scarf. Only Eisenhower and other field grade officers wore custom outfits in those days. However, Harvey was considered a hero and no one challenged him in his wearing of his unconventional uniform. When he got on board the B-24, he would immediately change into a flight suit. Before he left the plane he would change back into his dress uniform, including his yellow scarf.

The project consisted of a program to ditch three B-24s. Two would be modified for the test and one left in its usual battle ready condition. The first airplane would be heavily reinforced, especially around the bomb bay doors, to prevent any failure of the bottom. The second would simulate the type of reinforcement the crews were customizing before their overseas flight from Langley. The third plane would be a normal combat B-24.

The ditchings were to take place on the James River [Virginia] parallel to the James River Bridge. The bridge was a couple of miles long and the water was shallow at the test site. The technical personnel, to observe this test, were stationed on the bridge with many photographers and observers. The coast guard boat was standing by the staked out landing area. The first B-24, the one with maximum reinforcement and with Harvey as the pilot and me as the co-pilot, was to be first one ditched under these controlled conditions. We were to land parallel to the bridge and about 100 yards away from it. If the first ditching was successful we would proceed to ditch the second plane with the light reinforcement. And if that was successful, then Harvey would ditch the last plane, the one without any reinforcement, and show us how to do it.

When Major Harvey had been assigned to NACA as the pilot in all the tests, I was assigned to him as his co-pilot. We had six weeks to get familiar with the test program, the

approach to the test site in the James River, and any emergency procedures we needed. Harvey never practiced an approach to the test site and he never discussed emergency procedures. We spent the time flying around to various airfields in the vicinity and shooting landings. He let me fly the B-24 and land it from the co-pilot seat. That was the biggest airplane I had ever flown and it still is. I had just started flying the fighters when he let me fly this huge bomber. It was an awesome experience!

One day, about four weeks into the program, we found ourselves flying in the vicinity of Patuxent Naval Air Station [Maryland]. There were just three of us in the plane, Harvey and I and a crew chief, who was sitting on a jump seat between us. We heard another plane contacting Patuxent by radio. They were calling for an emergency landing saying that they had one engine feathered. The Patuxent tower cleared the traffic pattern and gave them permission to land. Harvey must have thought that these pilots, who would declare an emergency with only one engine out, needed to be shown a lesson. He reached up and pressed four large round red overhead buttons that feathered our engines. There was absolute silence in the airplane and an initial feeling that this plane is going to drop like a rock. But it was quite the contrary. The B-24 has a Davis wing, which is a high aspect ratio wing that has a very high glide ratio, and if anything, it almost felt like a Cub. It just seemed to float and descend relatively slowly as we entered the traffic pattern and turned toward the field. We were at five or six thousand feet as we turned into a final approach. The runway we were headed toward terminated at the Chesapeake Bay.

As we started the turn into “final,” the crew chief, who had been sitting between us, jumped up and said, “We don’t have any hydraulic pressure,” and runs to the back to start the APU or auxiliary power unit. We finally hear the unit going. Harvey was now able to put the

flap and gear down and now he had brakes. All of which he seemed to have forgotten about. He was committed to land the airplane and either he didn't realize what he had done or he didn't care. I don't know. But you'll get a read on this man later.

Anyway, we make the landing, but we almost overshoot and end up in the bay. As we come to a stop, an Admiral comes up along side of us in a jeep. He was accompanied by a bunch of fire trucks and other emergency equipment that had turned out with him. The Admiral hollered up, "What's wrong? What happened?"

To which Harvey responds, "Nothing! We're the crew from Langley Field and we are up here just practicing dead stick landings."

The Admiral was furious and yells up, "Get out of here before I lock you up. Don't ever come back here again." There were some other words and expletives that seemed to fit the occasion and his sentiments. So we got out of there and never went back.

Anyway, the day finally arrived for the ditching. I was informed that Colonel Greene, who was the military commander of Langley Field, was going to replace me as the co-pilot on the first ditching of the B-24. There was rumor that the crew was to be awarded the Air Medal for this flight. The Colonel did not have an Air Medal. I didn't either, but I probably was not eligible, being I was a civilian. So, after six weeks of flying with Harvey and practicing landings, I am left standing as an observer on the bridge and the Colonel is in the airplane.

Weather-wise, it was a flawless day on the day of the test. The first B-24 with the heavily reinforced bottom was fully instrumented and ready to go. All of the previous practicing paid off as Harvey makes a wonderful approach and levels out alongside the bridge. The Coast Guard boat and all the photographers and observers with their equipment are standing up and ready. Harvey touches down smoothly and the plane skims along for several hundred yards.

Suddenly it was if it had run into a wall. It just abruptly quit flying. It looked like it had broken in half. It sank immediately. The water was shallow at that point so the water didn't reach the top hatch, which Harvey opened and popped out. He reached down into the cockpit and pulled the Colonel out by the collar. Of course, the Coast Guard moved in and rescued the two of them from the plane.

What had happened was while the bottom of the plane in the area of the bomb bay doors had been heavily reinforced, everyone had forgotten about reinforcing the nose wheel door. As a consequence, in the run-out in the ditching, the plane finally settled low enough for the nose wheel door to make contact with the water. At this point, the nose wheel door caved in and the nose wheel and its heavy strut were driven up between the pilot and co-pilots. Obviously, the potential was there to kill either or both of them. So that was the end of the program and Harvey, and the other two B-24s were sent back to the Air Corps. The conclusion was not to ditch the B-24. It couldn't be done successfully, which is what we pretty much assumed before this test.

The point that I am trying to reinforce was that there were two types of testing going on at Langley during the war years. There were the basic aeronautical research programs such as on the all-movable tail. Then we had the quick response time programs such as the one on the B-24, where a solution to a problem in the shortest time possible was required. While this required a completely different engineering attitude and approach, the exigencies of the war required some quick answers. We were using the same engineers and pilots and the same test equipment—it was just the urgency and time frame that was changed.

The story of Major Julian Harvey doesn't stop with him as a hero and his rescue of the Colonel from the sinking plan. It was apparent that he fabricated the story of his successfully ditching a B-24 in the English Channel. Five years later he was involved in another incident,

when a car he was driving with his wife and mother-in-law went off a causeway in Florida. The two women drowned but he survived and inherited quite a bit of money from his wife's estate. He bought an off-shore boat and became a charter captain operating out of Miami. About five years after the causeway incident, there was an article in the national newspapers about Harvey. His ship, while out in the Gulf Stream and in stormy weather, sank with two families on board. Everyone, except Harvey, was drowned. Harvey rowed ashore in a rubber boat. Harvey said that the two men started a fight over whether to return to shore or continue in the rough sea and bad weather they had encountered. He said he couldn't handle the ship by himself and consequently it foundered. He tried to save the women and children but they panicked and hid.

About ten days after the ship went down with all hands lost, the Coast Guard started an inquest. While the inquiry was going on, one of their airplanes on patrol found a ten- or twelve-year-old girl floating in a rubber raft. She was a sole survivor from the Harvey shipwreck and she was badly sun-burned and dehydrated.

She told the story that while they were sailing in the Gulf Stream and in bad weather, Harvey had abandoned the ship after he had shot and killed the two men. The girl had seen this happen and ran up to the deck and hid. Harvey had not seen her leave the cabin and did not notice her hiding when he came up on deck. She told how he had gotten into an inflatable rubber boat and pulled away from the boat. As she came out of hiding, he saw her, but he couldn't row back against the strong wind that was blowing him away. Harvey had scuttled the boat and as it sank, some rafts which had been stowed on sticks, floated off. The girl was able to get into one of these and lay there, until she was picked up.

The news of her discovery, which occurred during the inquiry, was broadcast and appeared in the newspaper. Harvey, who was staying in a local motel waiting to appear before the board of inquiry that day, committed suicide by slitting his wrists.

JOHNSON: Quite a character.

CAVALLO: Yes he was quite a character. However he had nothing to do with NACA or Langley field. The atmosphere of the Pilots Office was all high-tech. We were all aeronautical engineers. We all loved what we were doing. Mel Gough was a tremendous influence. He had conceived the concept of using only engineers as test pilots in NACA. As I said, his attitude was that it was easier to make a test pilot out an engineer than it was to make an engineer out of a test pilot. And that sums it up.

JOHNSON: About how many pilots were there during that time period that you were there, how many test pilots?

CAVALLO: The pilot's office consisted of Mel Gough, Herb Hoover, Jack Reeder, Bill Gray and me. There is a picture of the five of us standing in front of a P-47 airplane, which they use in the current NACA website. You can see this if you go to Google and type in NACA P-47 Test Pilots. Joel R. Baker came on board and stayed about one year and then he went off to an airplane company test pilot assignment. There were a couple of others that came and went. It was hard to get pilots in those days as the eligible ones were joining aircraft companies who could pay more than the government and the military had all the others. NACA probably could

have gotten a military pilot if they wanted to, but the five of us worked six days a week and handled all the flying that was assigned to Langely.

Ames Research Center, Moffet Field, California had been started just before the war. We shared some of the aeronautical testing work with them. Some time about the middle of the war years, the Lewis Research Center, Cleveland, Ohio was started and began to handle all the engine research programs. We were still doing the engine research at the start of the war, in 1942. My first assignment, as an engineer, was to co-author a report called "Cowling and Cooling of a P-42 Type Airplane." The engineer in charge of the project was J. Ford Johnston. The P-42 was a modification of the famous P-40 Warhawk used by the Flying Tigers in China. The P-40 had a liquid cooled engine. The P-42 was same plane with a radial engine. Charles Lindbergh liked to use this plane to fly to Washington for the executive committee meetings.

JOHNSON: Did you ever hear from the gentleman that said he was going to arrest you if you went to Langley?

CAVALLO: Oh yes! The Colonel who said he was going to arrest me. No, I never heard from him again. I guess he went off to war someplace. When he said he was going to arrest me he also said, "Because you're mine."

JOHNSON: With that few pilots, and it sound like you named quite a few planes and different things you were flying, about how often did you fly.

CAVALLO: Oh, every day. I mean we flew on every flying day. Weather permitting. Oh sure it was a full load. One beautiful flying day, I was the only one available in the flight office. Everyone else was away or on assignment out of the office. I logged six hours of flying by literally leaving one plane and getting in another that had been prepared. It was a chance to respond to the requirement of the day, build up my flying time and show-off.

JOHNSON: What were your hours like?

CAVALLO: They were good, like eight in the morning till six p.m., everyday but Sunday. We flew six days. We knew we had it pretty good. We were coming home to wives and families and flying six days under ideal conditions. We weren't flying in bad weather. Certainly not test flying. Sometimes in transporting equipment and personnel or ferrying airplanes we would fly in instrument conditions, but generally that wasn't the case. That was the exception rather than the rule.

JOHNSON: And you mentioned that you were all aeronautical engineers.

CAVALLO: Yes, you had to be an aeronautical engineer to fly for NACA.

JOHNSON: When you first came, of course, you were working as an engineer before you became a pilot. When you were doing the different projects and flying, were reports created for all of the projects and all the tests that you did? After you got through, once the data was read by the

engineers and computers, and it was processed, were reports created for every one of those times?

CAVALLO: Oh, sure. Yes!

JOHNSON: Were you ever involved in these reports as a pilot?

CAVALLO: Only one report has my name on it which is "Cowling and Cooling of The P-42 Type Airplane" by J. Ford Johnson and S. A. Cavallo. But there are no other reports where my name appears on them, although our opinions were solicited. In many cases we helped design the flight program. We contributed in the meetings and conferences, and obviously we flew the programs and collected the data. Our job was to deliver the data that the engineer wanted and as Mel Gough often said, "To ask for answers to the problems or unusual conditions encountered in the test."

Jack Reeder had worked in the full scale tunnel for several years and I had work in the flight section. We both had an idea of the engineering aspects of what we were doing. I think that a pilot's name only appeared on the report if he had physically been asked to write a portion of it or it was his idea. Mel Gough and Bob Gilruth co-authored original reports on stability and control because Mel had designed and flown the original test flights and then supplied the parameters that were used as standards in handling quality reports. But the kind of flying I did could be thought of as, "working for the engineer." I wasn't asked to write any part of the final document. My writing contribution, after the P-42, was in the pilot report.

JOHNSON: But you mentioned you did have a good relationship with the engineers as you were working.

CAVALLO: Oh, you had to, sure. Because you were working for them. They wanted flight information. They were looking for certain parameters, certain details, certain points on a graph they wanted to fill in. There were certain areas they wanted to explore, and they'd want to determine if it was feasible to go there and do that kind of flying. In some cases we could help by suggesting "Don't do it this way; do it that way." It was a helping hand operation. That is what made NACA the effective organization that it was. We made significant contributions to the solution of aeronautical problems.

JOHNSON: When you were working as an engineer, how was that relationship between the engineers and the computers, and how did that work? The women computers.

CAVALLO: Oh, the ladies? They were smart. They were all math majors and helped work up the data, but like the pilots, if they didn't actual write anything in the report, their names were not mentioned. They were very, very good at handling detail work—some of them could do integral and differential calculus. They got into the basic work of reading the data on the manometer film and then correcting it for pilot or aeronautical induced anomalies that might have occurred. They were into the mathematical rather than the engineering part of the work. They were not aeronautical engineers. They were involved with the work-up of the data rather than the interpretation of it. They were proficient in the use of the 20-inch slide rules and the mechanical computers we had in those days.

JOHNSON: You mentioned a number of different airplanes you had experience with. If you had to venture a guess, how many different planes do you think you flew?

CAVALLO: I think it was close to seventy-five different models of airplanes. In the case of some, like the P-51, we had the A, B, D, and H models. But they were all different flying airplanes when they had been modified by engine, propeller and even changes in the body configuration. Although most of my flying time was in fighters, I was able to get to fly a variety of airplanes. This included fighters, bombers, helicopters, amphibians, transports and many types of civil aviation models. I had flown as a co-pilot in the Sikorsky S-38 as well as the twin engine Grumman Goose amphibian. I built up a considerable amount of time in seaplanes. As a result, when they needed a pilot for water or hydrodynamic tests, I was called upon to do that kind of flying. I had the chance to do a full range of flight testing. It was marvelous. It was a dreamy job.

JOHNSON: Was that something that you wanted to do, or did they ask you to do the hydrodynamic part of it?

CAVALLO: You know it just evolved. I would have asked for this assignment, if I hadn't been asked to do it.

JOHNSON: What was that like? The first time, maybe, landing an airplane on water, compared to on land, how was that the first time you did it?

CAVALLO: Well, again in those days it was fairly simple. The pilot that delivered the airplane, for instance, from the Navy, the ferry pilot would take you out and let you shoot a couple of landings with him, and then he would consider it "your" plane. It was considered demonstrated and delivered. It wouldn't be that easy today. Today there would be a whole course on the plane, reading the manual and then a checkout with a rated pilot.

Actually there is another way to answer your question. The major difference between and land plane and a seaplane was not in the approach and landing. It was in the maneuvering and "sailing" the plane with the current and winds, which had to be considered after you got onto the water. These forces of course were different and unique in the taxiing of a seaplane. My first landing in the Goose was in the creek at Wallops Island. The pilot that checked me out in the Goose took me up there and let me shoot a couple of landings. In those early days we had a buoy anchored in the middle of the creek, which we had to hook onto. There wasn't any chance to practice. It was like becoming a mother. All of a sudden, you've got the problem. Deal with it. In my first landing, the check pilot stood up in the bow and grabbed the buoy with a hook as I eased up to it. On that and for a while in the future, a local fisherman, hired for the job, would scull a flat bottom boat out to the amphibian and we would transfer people and equipment to the shore by boat. Shortly afterward, they built a ramp and we could put our wheels down and taxi up onto the shore.

This operation of landing into the creek had a lot of flight problems to overcome. It was a narrow creek, with a constant current that would reverse due to the tide and often had strong cross-winds. If you got one wing down on take off and buried the down wind float in the water, you might not be able to get it out. This would produce a turning moment that could not be

controlled by the rudder. This was called being "locked-in-irons." On one occasion, after I have left Langley, the pilot continued a take-off, while he was also turning, with the float "buried" in the water and ran into the dock sticking out from shore. They discontinued this operation. From then on they flew the people and equipment by landplane to the Chincoteague Naval Air Station and then continued by van and boat to Wallops Island. This caused a considerable increase in the time and handling requirements. After the war they built a road and bridge to the island.

Another story apropos of taking delivery of an airplane was when the Army delivered a De Havilland Mosquito to us. This was a British plywood fight-bomber. It was a twin-engine airplane that the ferry pilot brought to Langley and in which he took Herb Hoover for the check ride. Herb was the chief test pilot at that time as Mel had moved up to Division Chief in charge of engineers, pilots and mechanics. The two pilots sat side by side, but the co-pilot side did not have controls. The right side was designed for the gunnery and navigation officer. During this check ride the ferry pilot feathered an engine to demonstrate the airplane's one-engine capability and handling qualities. He feathered the engine that had the generator. In doing so, they lost their electric power. They had to crank the gear and flaps down by hand. This apparently became very "hairy," as the pilot had to do all this himself and apparently he wasn't all that proficient. Herbie swore he'd never let another ferry pilot check him out. From then on, he would read the manual while sitting in the cockpit and do the demonstration flight himself. However, he was a high time pilot with a lot of test experience.

So how did I get checked out in a fighter? I had never flown a big fighter, anything over 400 horsepower, when Herb put me in a Grumman F6F. Now, all of a sudden I am in an airplane that looked as big as this room. You are alone, solo, so nobody can come along with you. I got as much time as I wanted to read the manual and sit in the airplane to get familiar with

everything. But when I was sitting in the plane and getting ready to take off for the first time, I remember him saying, "Now, take this around the pattern and bring it back and don't touch anything. Fly it around once and land." Well the minute I applied power to this 2000 horsepower engine, all I could hear was this tremendous roar. I had never flown anything that big or powerful. So, I flew in around the pattern, left the gear down and the flaps up and made my first solo flight in a fighter-type airplane.

The F6F Hellcat happens to be an easy airplane to fly, very stable and with light control forces. Herb was right to put me in that kind of an airplane and to get me into the next level of flying from where I can transition from light planes, fewer than 400 horsepower, into the largest military single engines we had to test. There wasn't anything at Langley available in between, so I had to make the transition in one day. I don't know how the military did it at flight school. They probably had intermediate steps and equipment. But this is the way it was at Langley and Herb obviously felt I could handle it. Fortunately, I could and I did and that's the way it was. It was a wonderful time. A challenge, obviously, but that is not the way things are done at NASA today. The flight crews have to be graduates of the academy and mission specialists have to have a doctorate in physics or a specialty just to be considered for a flight.

When we got our helicopter, the Sikorsky YR4B, it really created a stir. Jack Reeder, who had done engineering studies in the full scale tunnel, was sent to the factory in Bridgeport [Connecticut] to get checked out. Sikorsky's chief test pilot, who had been checked out by Igor Sikorsky himself, checked Jack out. There weren't many helicopters or helicopter pilots. It proved to be a difficult machine to fly. Jack was only able to check three of us out. To a pilot who is used to conventional planes and their controls, this was like getting used to patting your stomach with one hand and rotating the other above your head. The stick in this early machine,

which was the first helicopter the military acquired, would rotate in a small circle in some cadence with the rotor. You had to hold the stick with a loose and flexible wrist. The whole concept of a long handled stick to control rotor pitch with a throttle at the end of it, rudder pedals to control a vertical rotating fan in the back, and a regular stick to control bank was a daunting task to many pilots. It took considerable practice to get proficient. The other pilots didn't want to take the time. I was shown how to get the machine up and down to about an altitude of 20 feet. Then I was shown how to rotate it to the right and left through 360 degrees over a fixed point on the ground. At this point I was on my own.

The apron or tarmac was divided into a grid of cement with score lines about 100 feet apart. I would start out facing north over one of the corners of the grid and rotate 360 degrees clockwise keeping steady on the corner. This in itself was quite an accomplishment. Then, with the helicopter still facing north, I would back up to the corner 100 feet behind me. At that southeast corner I would rotate through 360 degrees counterclockwise. Then with the machine still facing north I would move sideways, to the left, to the south-west corner of the box. At this point, I would do another circle clockwise, and then move forward to the third or northwest corner and do another counterclockwise 360 degree rotation and finish with a sideways flight home. The point was to stay exactly over the corner on the rotations and try to decrease the time it took to get around. It was pretty much like learning to play the piano by practicing over and over. When I felt that I could handle the machine with some ease, although it never lent itself to complacency, I simple gained enough altitude to circle the field and considered myself checked out.

The rotor head had to be changed or rebuilt every 100 hours and we mounted a camera on the hub pointing out at the rotor blade while it was turning. This should have seemed to be the

least of the concerns relevant to the operation of a rotary wing. We mounted a camera on the hub of the rotor showing the rotor blade in its transition. When I saw the flexing, bending, and twisting that occurred, it was remarkable to me that the blades didn't fail before the hub. I am considered a "Pioneer Helicopter Pilot" by the Twirly Birds, a fraternal organization of helicopter pilots, because I had soloed a helicopter in July 1945, before V-J Day [Victory over Japan, August 15, 1945].

JOHNSON: You mentioned the ferry pilots, and that just brought to mind I know during the war they were using women, of course, the WASPs (Women Air Force Service Pilots), as the ferry pilots.

CAVALLO: I still have a very good friend, Gloria Heath, who was involved in flying for the military. I met her at Langley. We became friends and still are. She lives in Greenwich [New York] and we have a dinner date next month. Whenever she had ferried a plane into Langley or was passing through, she would stop by our pilot's office to visit and so we all got to know her. She had met Mel Gough on a previous occasion and they had mutual friend in Jerry Lederer.

JOHNSON: That's what I was wondering, if any of them had actually brought the planes to you.

CAVALLO: Oh, sure. (I'd like to qualify this answer). Women pilots flew in and out of Langley and made deliveries to the military. In the case of Gloria, she ferried planes and also pulled targets for practice gunnery, at some peril to herself. Her plane had inadvertently been hit by gunfire on one occasion. After the war, Gloria, who was a native New Yorker, joined with Jerry

Lederer to found the Flight Safety Foundation. Jerry later became the head of the NASA safety program at the Cape [Kennedy Space Center, Florida].

However, to return to your question! No airplane was delivered to me personally, which your question implies. However, I wasn't present at all the deliveries made to NACA and it could have very well been that a WASP brought us an airplane that I didn't know about. I was aware though that the WASPs would come through Langley with B-24s on their way to England.

JOHNSON: How were they accepted, or how was the reaction to women bringing these planes that you were going to be flying and testing.

CAVALLO: It would have been a surprise to have a plane turned over to me by a WASP and even more so if she was to be the check pilot. It would have been a surprise just to see a woman step out of a military plane in those days. We had all heard of Jacqueline Cochran and Amelia Earhart. Amelia Earhart's Lockheed Electra was based at Teterboro and her mechanic, Ed Gorsky, taught me to fly in 1940 and 1941. He was the fixed base operator at Atlantic Aviation. Most of the women we ran into worked as line crews. The Navy used quite a few women in this capacity. I think more so than the Air Force. I don't recall seeing women on the line at Langley but they were certainly in the offices and in some phases of maintenance and support. I remember being surprised when I went around to thank the person who had packed the parachute which I had used to bail out of the P-51 and discovered it was a young woman. You had to get used to seeing women in a largely male environment. Except for the CPTP, there were no free flying lessons. Jacqueline, Amelia and my friend Gloria were all women of means and could afford to take flying lessons before the war. Gloria owned her own plane.

JOHNSON: That's interesting. For a minute, let's go back to when you were still in school and you heard about the NACA hiring. What were your impressions of NACA at that time? What did you know about it, or were you just going into this because it sounded like—

CAVALLO: Cowling manufacturer. No, I'm being facetious. We all knew about their airfoil and cowling designs, but I think all of us in the aeronautical school environment felt that NACA was just a very basic aeronautical research arm of the government, and doing only very basic research work. Nobody saw any glamour in NACA. Everybody thought that NACA consisted of a bunch of long-haired people sitting around working with twenty-inch slide rules and solving equations a half a page long. I'm sure I never associated flight testing with them. I don't know why. I had never thought of it. I just saw it as a pure aeronautical engineering operation.

JOHNSON: What were the facilities like when you first arrived there, as far as the actual physical facilities of Langley?

CAVALLO: I had arrived at Langley shortly before its explosion in growth and the arrival of the large contingent of wartime personnel that subsequently staffed NACA. Consequently they were still taking all the new engineers around and introducing them to the various tunnels and facilities and their personnel. This apparently was an established procedure dating from the early days. I, along with others, was taken around to every major facility and tunnel and introduced to all the various department, division and section heads. It was a thorough orientation tour. NACA had a really small, almost country-like kind of sense or feel to it, like a small laboratory.

That's a good descriptive word, a lab, in every sense of the word. They made it easy to know everybody, what they were doing and where they worked. You felt as if you knew everything you needed to know about NACA as you came on board. I think there were 3000 people at Langley with maybe 300 in the engineering phase, but that's a guess. In any event, they stopped these orientation tours shortly thereafter. I never thought I would get a job there. In fact I think I forgot about the fact that I had applied for a position there until the telegram came saying, "Report to Langley Field Monday morning." I was sure that I was going to be in the military and there wasn't any other way to go, that is, once the war started.

JOHNSON: Was there a sense, as you mentioned, since the war had started and that you weren't in the military, but you were working, obviously, for a very important cause, helping with the war effort, how did you feel about the work you were doing? I mean, as far as your contribution.

CAVALLO: Once I was there, I could see the significance of what I was doing. I was caught up in it right away. I was working with and surrounded by brilliant people. As an engineer right out of college, you realize how little you know. In fact, Professor Alexander Klemin said, "All you people have learned is where the information is. But don't try to design any airplanes, and if you do, don't try to fly them, because you'll kill yourselves." When I got to Langley, I realized how true this was. Those people at NACA had passed tough civil service exams, which we were not called upon to do, and they had worked in an area of pure research in the early development years of aeronautics. They were very bright people and they were doing basic research work. The start of the war meant that while basic research would continue, we had to aggressively move ahead. We had to dramatically improve the performance of our fighters and bombers

which were pitifully behind the Germans in every category. The significance became apparent when we realized we had to get our act together and fast. We were all caught up in the spirit and tempo required. My impression was that Americans have an attitude that it is every man for himself, unless there is a common cause they believe in. At which point they are able to get focused and come together in an incredibly cohesive way. And we did!

JOHNSON: What do you think, while you were at Langley and with the NACA, would be your most important accomplishment during that time period in your life.

CAVALLO: Well, fortunately I wasn't called upon to stand and deliver in an engineering sense, because as an engineer, I paled compared to these people. But I was called upon to fly airplanes with the basis of engineering and that made me appreciate what they were doing and what they wanted and needed. I tried to give the engineers the kind of data they would have obtained if they were doing the flying. Mechanically, I was a good pilot with an engineer's understanding. I could handle all the problems of test flying. I don't think I would have lasted through the preliminaries with Mel and Herb if I couldn't handle an airplane. And I could then and I still fly today. I have a Cessna 210 and love to fly it.

JOHNSON: Do you think the other pilots also, as you said, aeronautical engineers, attempted to do the same thing, to get the best data?

CAVALLO: I think so, yes. I think that's why we were chosen, why we served this apprenticeship. Don't forget that this was Mel Gough's concept and idea, and he was right.

You've got to bake the bread if you want it to taste good. You've got to be part of the scene. You've got to have had your hand in there. And it worked, and I'm sure all of the five engineering pilots that I knew were competent and conscientious. It is interesting that anyone who had not been through the training program we had, which had combined engineering and flying, lasted as test pilots.

Let me add though, that at the farewell party they gave me when I left Langley, one of the engineers I had done a lot of flying for said in his send off speech to me, "We are now losing our tracks in the sky."

JOHNSON: It seemed to be a different situation than some of the other test pilot areas, where they were military. I guess what we know about the test pilots at Dryden, that they were always pushing that envelope on the flight, it was a different type of test flying as far as new, different types of aircraft, whereas you, at this time period, you were testing aircraft and trying to find out where the problems were and to solve those problems.

CAVALLO: Yes! We were looking for limiting parameters. We were looking for points on the curve. We were trying to fill in the equations. You know it was flight engineering. Our title was Engineering Test Pilots. It wasn't just Test Pilot. It was Engineering Test Pilot. That was an official label and title. The military pilots were good and they were brave. They were the pilots that tested the envelope. Can this plane dive to Mach .85 or whatever and still pull out? In the case of X-1 we had the big conflict. There were two X-1s both designed by NACA. However, it was Air Force money. The military got control of one of the X-ls that had a thin wing. NACA got one with the thick wing. The NACA concept was to do a series of flights leading up to the

speed of sound with engineering control all the way. The Air Force saw the public relations benefit to this problem and using NACA engineering talent under Walt Williams and the all-movable tail, which was an NACA invention, they accelerated their program and went through the speed of sound. It was a big disappointment to NACA. The speed of sound would have been exceeded either way, but it would have been done differently if NACA had prevailed. Their airplane, with the thick wing, exceeded the speed of sound as well, a short time later.

JOHNSON: You mentioned that you left in November of 1947. Why did you leave at that time?

CAVALLO: It was partly personal. I was asked to go to Edwards [NACA Muroc Flight Test Unit], specifically to fly the Douglas D-558 plane and as a potential pilot of our X-1. The D-558 was a jet propelled airplane that could take off and land from the airport and using its own jet power, exceed the speed of sound. The X-1 was rocket powered and had to be carried to altitude by a B-29 bomber and dropped. This was before we had gotten through Mach 1. The war was over. My wife and I were both native New Yorkers and I was being offered a family business that was to be taken over or sold. My wife had some strong feelings about Edwards. The wives who were returning from the area said that the temperatures in the summer were over 100 degrees and the cooling was from water dripping through cotton and blowing into the Quonset hut by fans. There were no school facilities and I had a son. We had been making two trips a year to New York by driving from Virginia. There would have been a significant travel expense from California by train. I asked for an increase in pay as I was a P-3 getting $5,000 per year. I had also asked for a seat ejector to be installed in our X-1, if I was to fly it. I had bailed out of one airplane on fire and nearly lost another P-51 when I got into a flat spin from 20,000 feet to

about 5000 feet before I was able to recover. And I had been in several other "incidents" that generally go with any kind of test flying. I was well aware of the impossibility of getting out of an airplane in trouble at supersonic speeds. It just didn't make sense to me to spend all the money and time on this project and make it impossible to get the pilot out and back if the plane was lost. And if the plane and pilot were lost, it would be months and maybe years before they could try it again. I was told by one of the leading engineers on the project that, "If you consider this flight dangerous you shouldn't do it and if it is not dangerous, you don't deserve a raise."

About this time, October 1945, [Charles E. "Chuck"] Yeager went through the speed of sound. So the challenge was gone. Furthermore, I felt that my position in flying for NACA was compromised by the position I had taken on the salary and ejection seat. While I was mulling over the foregoing considerations, an offer came to me from Edo Corporation in College Point, New York City as a test pilot. I was offered a job as a test pilot with a unique compensation package. They offered to pay me $100 per flying day. A flying day was one with a cloud ceiling of 1000 feet and a visibility of greater than 3 miles. On the other days I was free. On the free days I could participate in the furniture business. The motivation was overwhelming for me to come back to New York and go for it. So for two years I flew for Edo for $100 per flying day and when it wasn't a flying day, I was in the business of manufacturing furniture. By that time the Edo Company ran out of airplane orders and went out of the aircraft business. The next job offer was from Chance Vought in Austin, Texas. By this time, I was 29 years old, didn't like what I saw on a visit to Austin and was beginning to like the role of a business man with civilian flying on the weekends.

JOHNSON: But you still fly.

CAVALLO: Oh sure, I've been flying since 1941 when I got my license through the CPTP at Teterboro. Last weekend I flew to the Nantucket Air Show [Massachusetts].

JOHNSON: Is there anything that we haven't talked about during your time at NACA that you'd like to mention, or anything that we've neglected to mention.

CAVALLO: No, except to say how bureaucracy tends to muddy up the waters. For example, we fought and won a war, built a tremendous production complex, went through the speed of sound and did most of the preliminary engineering work leading to the Moon shot using slide rules that give you an accuracy of maybe 1 – 2 percent. Now they actually quote some stocks to six decimal places. As we spoke about, some things can be done easily, quickly and cheaply but the longer it takes to do something and more people that get involved, the more complicated and costly it gets. Test pilots were made from people that were physically and mentally able to do the job. It gave me an opportunity that would probably never be afforded me today. Problems were solved, whenever possible, by trial and error. Things were simpler and in some ways better in those days. It was a marvelous time and I enjoyed every minute of it.

JOHNSON: After, of course, when NACA then changed to NASA and when the space program began, did you ever think about going back into it or rejoining?

CAVALLO: Interesting that you ask that. Right after I left NACA and came to New York I received a card from a very good friend of mine, a top engineer, who had gone out there to

Langley to consult. He said that he thought it was the place for me to be. I appreciated hearing this and especially from him. And achievement-wise, Muroc was on the leading edge of high speed flight. However the pilot who they asked to go when I didn't was killed within six months in a D-558. This was supposed to be the "safe" way to go through the speed of sound. This rather conventional jet engine blew up on take-off and killed Howard Lilly. Joe Walker, who replaced Howard Lilly from NACA Cleveland, was killed when his Lockheed 104 hit the B-70 Valkyrie killing Joe and one of the B-70 pilots. Of course that doesn't mean that this could have been the same. It just shows that test flying is a dangerous game. Yeager was right when he called himself, "a lucky man."

To get back to your question, yes, I applied and was accepted as a mission specialist every year until recently, when I stopped applying. However, they kept accepting my application and indicating I was being considered. They would also notify me when I was not in the final choice.

JOHNSON: As far as for the Shuttle?

CAVALLO: Yes! As far as being eligible. My resume was interesting. I had been an NACA test pilot, I was an engineer trained in NACA procedures. I had flown jets at Langley. I was a current pilot and still could pass a flight physical and I had single and multi-engine land and seaplane rating including time in helicopters and gliders. Except for an advanced degree, I was probably better qualified than most for being part of the non-flying crew. I kept applying to JSC [Johnson Space Center, Houston, Texas] and they would accept my application and then follow that with another letter when I was not chosen. So the next year, I would apply again. Three or

four years ago I stopped applying. Up to the time that John H. Glenn, Jr. went into space, I figured that they were still looking for geriatric statistics and maybe I could contribute something using my ancient body although I am still physically fit. However, Glenn went into space and they probably got all the information they wanted on geriatrics. So now I come to JSC to visit my old NACA friends Jerry [Jerome B.] and Adeline Hammack and Chris [Christopher C.] and Betty Ann Kraft, [Jr.]. Maxime A. Faget was also a Langley Field acquaintance, but he died recently.

JOHNSON: And as you mentioned, there were some very well known names that were at Langley when you were there and that moved through Langley.

CAVALLO: Oh sure! Bob Gilruth and Mel Gough, and engineering wise, T.J. Voglewede and J.W. Wetmore. There's a whole litany of outstanding people. They were the founding fathers of aerodynamics. They were also the pool of talent they drew from to create NASA. Without NACA and Langley Field they would have had a tough time starting the space program. Langley Field also provided the cadre of people when they started Ames and Lewis. Langley was the cradle of aviation and I was privileged to know a lot of really brilliant people and see them perform. And in keeping with your statement about the well known people who passed through Langley, there were two that I was privileged to have seen. Orville Wright came by Langley field and Mel Gough drove him around the field and escorted him to lunch with all the major players at Langley. So some of us got to meet him. Last year in Houston, I sat at the head table with Chris Kraft and Neil [A.] Armstrong, who had been an NACA pilot and had passed

through Langley Field. I feel privileged to have met the first man in flight and the first man on the Moon. Aviation and space have only been around a single life span. Mine!

JOHNSON: You were definitely there during an amazing time.

CAVALLO: Yes! And most of it has not been recorded because of the lack of publicity on what we were doing and what we accomplished. I remember being cautioned about talking to anyone about what you were doing, not even to your wife. Of course there was a war on too. Even when I bailed out and was dropped off at my apartment carrying my parachute, I didn't discuss the mission. Herb had called her up and told her I had bailed out and that I was okay. I went to work the next day, and wrote a report on the incident and was back flying the day after. It wasn't expected that you'd take a week off and recover from the trauma of it. They didn't offer it and I didn't want this kind of treatment. But it was a different way of life.

JOHNSON: It's hard to compare.

CAVALLO: True!

JOHNSON: We appreciate you talking with us today, and I've really enjoyed it. That's a special time in the history of NACA, and quite amazing, some of the things you were accomplishing.

[End of interview]