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Space Shuttle Endeavor completes its maiden mission, STS-49, landing on Runway 22 at Edwards Air Force Base on 16 May 1992. It was the first exercise of Development Test Objective (DTO) 521, Orbiter Drag Chute System, deployment of the drag chute. The mission was extended to nine days to retrieve the Intelsat VI satellite, which failed to leave low earth orbit two years earlier, attach it to a new upper stage in the payload bay, and relaunch it into geosynchronous orbit.
Dear NAA Retirees Bulletin Subscriber

Well, it is done! After an amicable discussion with the United States Air Force Academy, your North American Aviation Retirees Bulletin has arranged to sponsor three outstanding scholar awards at the Academy and one at the Academy Prep School. The awards will be made starting in 2010 and will be presented each year in perpetuity. To accomplish this, the Bulletin volunteers reached deeply into our contingency fund to establish a trust fund for each award. The interest earned from these trusts will provide the actual awards presented to the cadets and the cadet candidate. These awards are usually sponsored in the name of an outstanding person. Our awards will bear an unusual cachet in that they will be sponsored in the name of a company. They will be the final salute to a great company, Our Company! They will salute North American Aviation, Inc. We think it is only appropriate that the name be connected to young people who have volunteered to serve and defend their nation in the skies and the heavens!

In this issue we have an old friend, Chuck Lowry, discussing the development of the Shuttle Drag Chute. Readers will recall Chuck's article about the Apollo chutes. He is the world's most knowledgeable engineer on parachute design and his description of the idiosyncrasies of individual parachutes provides a ready lesson on parachute design. Every parachute seems to have a "life" of its own. As a result, there are so few technical references available that the engineering almost becomes a "black art".

The new historian at Edwards AFB has agreed to provide us a series of articles on the first flight tests performed at EAFB of North American aircraft and missiles. For his first article he chose the X-10. This brought back several memories which are dutifully reported in a small sidebar.

We also have a very neat article by another old friend, Stan Barauskas, on the Quarter-Scale Space Shuttle Model that was used to conduct vibration tests of various Space Shuttle configurations at the outset of the Space Shuttle program.

Finally, we asked our P-51 historian, Lowell Ford, to comment on Christopher Shore's article. His reply ended up being an article that complements the one provided by Christopher so we are pleased to present it in this issue.

One of the greatest joys of being the volunteer editor of the Bulletin are the fantastic people that cross your path. Some are associated in some manner with North American Aviation but others are simply people with "heart". Perhaps, they recall the roar of a P-51 overhead, the tingling whine of an F-86, or the thunder of a Space Shuttle leaving the pad. Whatever the reason, when asked to help they only reply, “When do you need it?” God Bless them all.
Since Captain Chuck Yeager blasted through the “sound barrier” in the Bell Aircraft Corporation’s X-1 in October 1947, Edwards Air Force Base (EAFB) has become synonymous with the famous “X” series of experimental flight research aircraft. Throughout the decades these aircraft were designed to explore the unknowns of flight and solve their mysteries. Many of them, such as the X-1, were rocket airplanes built to probe and expand the frontiers of flight in terms of speed and altitude; others, like the X-5, the X-13 and, more recently, the X-48A were designed to evaluate new concepts and technologies which might be applied to future aircraft designs.

One of the more unique “X” craft tested at EAFB over the years was the unmanned X-10, built by North American Aviation, Inc., to support the SM-64 Navaho missile program (Project MX-770). The Navaho cruise missile program had begun in 1946, and signified one of several post-World War II missile research efforts undertaken by the U.S. Air Force. The objective of the program was to determine if an intercontinental weapon – such as Nazi Germany’s planned A-9/A-10 New York rocket – was indeed possible. The basic mission of the X-10 was that of an aerodynamic and systems test bed for the upper, second-stage cruise component of the Navaho missile.

Specifically, the X-10 was to serve as a test vehicle for operations at supersonic and subsonic speeds to ascertain stress, temperature, guidance, control and aerodynamic conditions which were to be met by operational missiles. The X-10 was also evaluated as a cruise missile candidate on its own merits, to be armed with a nuclear warhead and capable of taking off and flying to a target under its own power. Finally, serious consideration was given to making the X-10 into a ramjet engine test bed; yet intake design limitations and simple economics led to the demise of this proposal.

A total of 13 X-10s were built by North American at the Downey facility; of these, only 10 would be test flown. The basic design was a low delta-wing canard configuration with side air inlets. The “futuristic” looking X-10 sat on tri-cycle landing gear and featured a pair of twin vertical stabilizers, canted outward – a configuration common today but unknown in the early 1950s. A pair of canard wings extended from either side of the craft’s long nose and its lithe, sleek lines – unbroken by a cockpit – suggested an air vehicle capable of unusually high speeds. Far aft, the robust engine section with its dual air inlets hinted at high levels of engine power.

Photo from the EAFB History Office

The X-10 inside one of the two hangars located on the flight line at South Base at Edwards AFB and shared with other X-planes.
Two Westinghouse XJ40-WE-1 engines were accepted and installed in the first X-10 and used for ground run-up, rehearsal flights, and first flights. These engines were rated at 10,100 lbs. static sea-level thrust (in contrast to the 10,900 lbs envisaged in the original specifications). In its later configuration, the X-10 was powered by two Westinghouse J40-WE-1 afterburning turbojets – each rated at 10,900 lbs. thrust in full afterburner and 7,250 lbs thrust in military power. Normal rating was 6,500 lbs of thrust.

The X-10's airframe was constructed largely of aluminum, with some magnesium parts in appropriate places. To address heat concerns, stainless steel was used in the empennage section around the power plant compartment, while internal structural assemblies were manufactured of machined and cast aluminum and magnesium. The turbojet power plants were installed in two nacelles blended with the after body.

Following static ground tests by the contractor, the first flight-ready X-10 was trucked to EAFB in May 1953. A large portion of the program activity at Edwards was devoted to ground functional tests which were necessary to establish the proper operation of equipment; and, following delivery of the first test article, an initial period of three months was used to conduct a complete checkout of all systems. Two successful taxi tests were also completed with the first X-10 to provide intermediate operational tests of both equipment and control procedures prior to flight.

These vigorous preparatory efforts culminated in the first flight of North American’s X-10 on 14 October 1953. The initial flight had been planned to take place a week earlier, but was cancelled following failure of the radio control system. Now, in the final hours before the flight, contractor technicians worked feverishly to ready the craft’s control system, in the process replacing a voltage inverter unit and replacing a burned-out alternator. As the day approached its end, the technicians finally completed their work and the X-10 was again ready to fly.

With all systems “go” and weather conditions ideal, the X-10 roared down its lakebed runway and lifted off the ground. The objective of this initial flight was to determine the air vehicle’s flight worthiness and its flight characteristics at subsonic speeds. The test article for this flight was GM-19307, or X-10 No. 1. Following launch, the missile became airborne at a speed of about 160 knots and climbed for altitude. During the flight it reached a maximum speed of 350 knots and an altitude of about 21,000 feet. The X-10 was controlled by a ground controller and a Lockheed ET-33A chase plane. The ET-33A was outfitted with a complete radio control system, enabling it to control the X-10 during takeoff, cruise flight and landings. The Lockheed chase plane then shepherded the missile back to Edwards Air Force Base for a perfect landing.

The X-10 had flown 172 miles and remained airborne for about 32 minutes. From the perspective of the test team, the flight was a success; simply stated, it verified control system data which had been obtained from the three conventional surrogate aircraft assigned to the program: the ET-33A; the Lockheed QF-80C drone; and the North American F-86D, which had been equipped with a prototype PIX10 autopilot. The second flight of the X-10 followed several months later, on 5 December 1953. The purpose of this test mission was to evaluate the ground control system and out-of-sight operating techniques. The flight lasted 35 minutes and 18 seconds, with the X-10 climbing to 24,400 feet and attaining a speed of Mach 0.71. All test objectives were met.

The first Navaho X-10, GM-19307, was trucked to Edwards AFB in May 1953. In the process of lifting the missile off the truck bed, the crane’s clutch slipped and dropped the vehicle back on the truck bed. The main landing gears became wedged in the truck bed and it required dismantling much of the truck to finally release the vehicle. After undergoing extensive testing in the hangar, the X-10 stands proudly on the lakebed, poised for flight. Encountering several delays, failures and countdown aborts, GM19307 finally roared down the runway on October 14, 1953 and flew successfully for a total flight time of 31 minutes, 40 seconds and a distance of 195 miles.
With X-10 flight testing underway, the Air Force was looking ahead to a time when unmanned high-speed missiles could be employed to strike hostile forces without risking interception from enemy fighter aircraft. One candidate was North American’s XSM-64 Navaho. This was envisaged as a supersonic ramjet with a range of 1,500 miles, to be launched vertically by means of a large, liquid-fuel rocket booster. The concept was extremely advanced for the early 1950s; the technological challenges formidable. As a result, the Air Force specified a supersonic turbojet test bed as the first step: the X-10.

At Edwards AFB, technicians marked off a 21,000-foot runway – 07/25 – at the far south end of Rogers Dry Lake. There, several X-10 test articles completed a total of 15 successful flight tests through March 1955, with 10 of these missions contributing to the attainment of primary test objectives. Indeed, the airworthiness of the basic X-10 airframe, power plant and overall configuration was successfully demonstrated for subsonic conditions throughout the 15 flights, while airworthiness and equipment operation in the supersonic regime was successfully demonstrated during Flights 4, 8 and 10 at Mach numbers up to 1.84 on the 10th flight, on 28 September 1954. In general, mission performance confirmed design specifications under the test conditions encountered. For example, a series of test maneuvers – including acceleration from Mach 0.9 to Mach 1.84 and a two g pull-up at Mach 1.84 – verified the structural integrity of the design.

In March 1955, the long-pending decision was made to transfer all X-10 assets from EAFB to the Air Force Missile Test Center (AFMTC) at Cape Canaveral, FL. Testing there commenced in August 1955 and continued through early February 1957, when the X-10 completed its 27th and final flight. On its 19th flight (at AFMTC), the North American missile reached a maximum speed of Mach 2.05, setting a new speed record for a turbojet-powered aircraft. While the original X-10 program had envisaged 40 test flights, technical difficulties with the SM-64 Navaho missile – coupled with the development of more sophisticated ICBM designs – led to early termination of the X-10 flight test effort.

Nevertheless, the X-10 was successful in achieving its primary design objectives, in the process making vital contributions to the Navaho missile program. The unmanned X-10 verified the aerodynamics of the upper, second-stage vehicle and the hardware associated with its sophisticated navigation package. Indeed, the operational test flights validated the system’s telemetry, autopilot, auto approach and landing systems, helping to build a technology base for the remote control of high-performance aircraft. The X-10’s twin vertical stabilizers proved optimum for sustained high speed flight, and the concept has been used extensively ever since. Finally, the X-10 had the unique distinction of becoming the world’s first Mach 2.0-capable turbojet aircraft to be employed as a target drone.

About the Author: Dr. Luther was a Fulbright scholar in Germany. He received his Ph.D. from UC Santa Barbara in 1987. He has written several books on German military history and has served as USAF historian since 1984. His first assignment was at McClellan AFB. Since 2000, he has been an Edwards AFB historian.

X-10 Memories of Edwards AFB

The photo of the X-10 in the hangar at Edwards AFB provided by Dr. Luther brought back some vivid memories of another time, another life. In 1953, I was an engineer in Downey working in the Stress Group on the Navaho program. We were all working on the G-26, the second version of the Navaho. The first version of the X-10, were still being assembled out in the shop and I was assigned to resolve all structural issues out on the production line. All of the other engineers gave me their stress analyses which I kept in note books by part number.

The first X-10, Tail Number 19307, had been delivered to Edwards in May and was being checked out for test flight by NAA field personnel.

One Friday afternoon in June, my supervisor, Chuck Rose, called me over and informed me to pack a bag on Monday because I was going on a trip to Edwards AFB. Evidently, to save time in case an emergency arose, a Stress Engineer was requested to be on standby at Edwards. On Monday, I reported to the flight line at Downey. The dispatcher checked his manifest and waved me aboard the C-47 which had been recently bailed from the Air Force. The interior was still paratrooper ready with metal seats running the length of the cabin.

The pilot came aboard, knelt down and pulled up the ladder and slammed the cabin door shut. He announced, “Everyone put on a parachute!” Since this was my first trip, he showed me how to strap the chute on and where the ring was in case I had to jump. We settled down. The pilot climbed into the cockpit and after a brief warmup, we were airborne. For three months I made that flight every Monday morning only to be returned every Friday evening. Except for my name on the manifest, I don’t think there was any record of me ever being on the aircraft.

We landed at Edwards and taxied over to the Flight Ops shack. I checked in and was assigned a room in the Bachelor Officers Quarters (BOQ). The airfield consisted of two giant hangars, the Flight Ops shack and the BOQ located on this vast dry lake. Some distance away was the formal military base. I dropped off my bag in my room and reported to the hangar where the X-10 was undergoing testing. It was like entering a World of X-Planes!

Our hangar was a fantastic array of historical aircraft. Next to the X-10 stood the record breaker Bell X-1A, behind stood the Douglas XB-43 jet bomber. It was the jet version of the very unique XB-42, known as the “Mixmaster” because it had two contrarotating propellers located behind the tail. Another unusual plane in the hangar was the Northrop X-4 “Bantam” hi-speed tailless experimental aircraft. To complete this medley of speed machines was a North American Aviation F-86D equipped with a PIX10 autopilot, a Lockheed QF-80 radio controlled drone to test the X-10’s radio control and a Lockheed ET-33 to control the X-10 during takeoff, flight and landing. It was exhilarating just to stand in the midst of all these magnificent flying machines!

I must add, it was not all work and no play! An NAA colleague stationed at Edwards took me to the Officers’ Club one evening where I met the newest NAA test pilot hired from the Air Force and his charming Australian wife. His name was George Welch. We also went for dinner to “Pancho’s” where I met the famous or infamous aviation pioneer Florence Lowe “Pancho” Barnes.

—Ed Rusinek
It all started with Astronaut John Young. John had commanded the Apollo 16 Lunar Mission and was standing on the surface of the Moon when he heard the official announcement that the Space Shuttle Program was to move forward. He was soon volunteered to command and fly the ALT (Approach and Landing Test) flights in which the Enterprise (first Orbiter, capable of atmospheric flight only) was to be carried to altitude “piggyback” on top of the NASA 747, released, and flown dead-stick back to base and landed. He did it well and made it look easy. John became a powerful voice in the early days of the Space Shuttle. And he knew more about landing the Orbiter than anyone. After the ALT program, he was entrusted to fly the first Shuttle orbital mission. A very competent and gutsy guy.

John's voice continued to be very important in the following years as the Shuttle matured and served the nation. After the Challenger disaster in 1987, the Rogers Commission was established by President Reagan to manage the determination of failure cause, corrective action, and steps back to resumption of flight. Its charter also included a broad examination of safety issues across the program to ensure safety through all phases of operation, reminiscent of the huge effort that followed the fire on Apollo 1, 20 years earlier. John Young had much to say to the Rogers Commission, and people listened.

After 25 successful landings and then the Challenger accident, John's widely-distributed letter of January 26, 1989 in which he stated, “Many people believe the next Space Shuttle accident will be in the landing phase”; and “The United States is betting the Space Shuttle Program on the crew's ability to perform with an Orbiter Landing and Rollout System that is, at best, intolerant of routine aircraft operating problems such as single tire leaks, nosegear steering malfunctions, or unexpected crosswinds.”

As a result of that letter and other forces, studies were conducted at NASA and Rockwell to determine the feasibility of installing a drag chute on the orbiter, and what it would look like. Should it be a single chute (like on most fighter aircraft) or a cluster of 2 or 3 (like on the B-70)? What kind of system would be needed to deploy and inflate it behind such a large fuselage? What kind of exotic textile materials would be required to put it in an acceptable range of weight and volume?

Perhaps the biggest initial concern was the huge aerodynamic wake behind the landing Orbiter, which would tend to inhibit the ability of a parachute to deploy, solidly inflate, and provide the needed drag. There was this huge forebody with a blunt aft surface, high angle of attack, elevons, and speed brakes; a hostile environment in which to deploy a parachute. What if it didn’t inflate?

If that’s such a big problem, what about bringing the Orbiter home like we did so successfully on Apollo? Naaaw! Maybe not.

A drag chute had been a part of the original Orbiter design, but to save weight had been deleted along with its stowage provisions early (1974) in the program. Finding a place to stow this newly conceived addition became a major problem. There were a few “nooks and crannies” around the vehicle, but could they be used? Many possibilities were examined.

In reality, a parachute must be installed and deployed from a point aft on the structure to ensure no recontact with the structure as it deploys and trails back. The options were limited, but a suitable place was eventually created on the vertical tail above the 3 main engine bays and below the speed brakes.

The best choice for the Orbiter drag parachute was determined to be a single conventional ribbon canopy similar to the SR-71 (40 ft diameter), but with extensive use of Kevlar (in place of Nylon) in the structure of the chute to save weight and volume. Also certain shaping modifications were incorporated to improve the efficiency of the drag-producing canopy.

The ribbon parachute is widely used in many applications. It was developed in Germany during the 1930s and its drag surface is made up of 2-inch wide Nylon ribbons. Actually the inventor, Theo Knacke, built his early chutes from haband material, which happened to be 5 cm in width—we call that 2 inches. Theo actively consulted with us in the development of the Orbiter drag chute.

A pyrotechnic mortar was designed to fire and deploy a small (9 ft diameter) pilot chute into clean air far behind the Orbiter, so it could pull the main canopy aft of the severe wake region for positive inflation and good drag.

Wind tunnel tests were conducted to determine how far aft the parachute canopy be to produce respectable drag, and a riser length of 87 ft was shown to be satisfactory. With a maximum deployment velocity of 230 knots, the maximum design load of 100,200 lbs with dispersions was established.

The Vertical Motion Simulator (VMS) at NASA’s Ames Research Center produced some of the most revealing information on usage of the drag chute. This is the 6 degree-of-freedom facility where much of the astronaut training for landing was and is conducted. It has a high-fidelity cockpit with flying qualities like the Orbiter. The VMS was the perfect tool to evaluate the drag chute and to develop landing procedures. It could simulate wind conditions and failure conditions such as control system problems and blown tires.

The Orbiter normally touches down and rolls a long way with its nose high. It was desired to deploy the drag chute as early after touchdown as possible to make it most effective. But since the riser is attached to the Orbiter so high on the tail, the sudden application of a high drag force at that high attach point tended to pull the nose even further up, increasing the angle of attack and causing the landing Orbiter to skip off and go airborne again. Not good.

So reefing was incorporated into the parachute design to allow early deployment while limiting the force fed into that high point on the structure. Reefing allows the canopy to inflate only to a certain diameter, then after a preset time delay (and further slowdown) allows full inflation. This configuration and the technique of initiating chute deployment after main gear touchdown and just as the nose starts to drop (deter-
The parachute stowage compartment is ideally located in the tail section of the Orbiter, where the airstream passes on either side of the compartment and aids in the deployment of the door and pilot chute. The pilot chute mortar faces aftward. When it fires, it shears the rivets that hold the metallic cover on and the pilot chute then proceeds to full stretch and inflates in about 1.0 sec. The force produced by the inflated pilot chute (about 4,200 lb) applies tension to the 2 cut-knives that sever the Kevlar cords holding the main chute pack in the compartment. The main chute pack is then accelerated aftward at 30 to 40 g, so clearance with the main engine bells is assured.

Before all that happens, the compartment door must be removed. The door has a unique jettison feature whereby it swings open on breakaway hinges by force from firing the mortar. The door is just a lightweight aluminum machining with TPS on it. Strangely, the machining ended up looking just like the door on the Design Group repro machine.

The door swings open under the force of the pilot chute pack emerging from the mortar to approximately 45 degrees at which point the hinges disengage and the door becomes a free-flying projectile. The hinge breakaway point is carefully defined to ensure the door trajectory carries it aftward (relative to the Orbiter) between the starboard OMS engine pod and the main engine bells, ensuring no contact. The door then trails the Orbiter and frisbees along behind it until it hits the runway.

The pilot chute mortar is fired by a single cartridge with dual electrical initiation. The muzzle velocity is in excess of 150 ft/sec, which ensures the pilot chute is carried well beyond the area of extremely dirty air trailing the fuselage so that positive pilot chute inflation will occur. The entire process from mortar initiation until full main chute inflation is about 5 seconds.

The parachute system including the compartment and door, was flight-certified by 8 deployments behind a landing B-52 at Dryden. Obviously we could not duplicate the blunt forebody, high attach point, or even the maximum landing velocity, but deployment, inflation, reefing, and door behavior were verified by those successful tests prior to installation on the Orbiter. The first Orbiter landing with the drag chute was STS-49 on May 16, 1992.

An interesting problem in parachute technology came up after a few flights. Our inability to initially test the drag chute system in a wake environment simulating the Orbiter led to a problem with parachute stability. The parachute canopy was originally designed with a low porosity to ensure positive inflation in the extreme wake field trailing the landing Orbiter—Parachute designers never, never, never want to field a career-ending chute design that fails to inflate. Low porosity encourages inflation in a strong wake field so we leaned that way. But low porosity also causes a parachute to want to fly at an angle displaced from the direction of airflow and that seemed to be the instability we were experiencing. On the early Orbiter flights the drag chute was found to seek out a stable position of about 7 degrees to one side or the other, causing extra pilot workload. Since observed inflation seemed to be very positive, it was judged that the canopy porosity could be safely increased to make the chute more stable.

So we took some parachutes to the very large 80 by 120 ft wind tunnel at Ames and experimented with various schemes to increase the stability of the canopy. The most effective means was found to be increasing canopy porosity by simply incrementally cutting ribbons out of the canopy at key locations and measuring canopy oscillation. A small, lightweight sensor was
placed in the center vent area to indicate by means of tracking photography the canopy excursions (angular oscillations) at the various porosities tested (see below). The bottom line was that by removing 5 of the 97 concentric ribbons, stability was excellent in the tunnel and loss of drag was minimal. This change was incorporated and all subsequent Orbiter landings have been free of the stability issue.

The only other notable issue was on John Glenn’s STS-95 flight in 1998, when the parachute compartment door inadvertently jettisoned at launch. As the main engines were coming up to full thrust, the door was seen to come off and get caught up in the main engine plume which carried it down the flame bucket. So we had an Orbiter in flight without a door. This became an extremely uneasy situation because no one knew the condition of the now-exposed main pack retaining ties, or the temperature of the mortar pyro cartridge, and it suggested the chute might deploy at any time during the flight. It did not deploy however, but remained in its compartment through orbital insertion and the entire mission.

But in true manned spacecraft fashion, many groundlings spent the next several days (and nights) thinking up all the horrible things that could happen if the chute deployed prematurely—and of course, what to do about it. Like what if it deployed in space, flailed around, and became wrapped around the vertical tail so that the rudder and speedbrakes couldn’t function. In such a case, would the chute burn away during entry, or hang around and cause problems? Or how about this one—what if it deployed just as the Orbiter was about 40 ft altitude during landing approach causing the Orbiter to touch down short of the runway, or at least endangering an already-difficult landing sequence? Fortunately none of these things happened and landing was normal, but the chute was intentionally not deployed to avoid introducing uncertainties. Post-flight inspection showed signs of enough heat to melt some non-structural Nylon on the face of the pack, but otherwise the chute and compartment were in good shape. A specific cause for the anomaly was never determined, but tolerances and controls were tightened up and no further problems have occurred.

People ask if we reuse the chutes. Yes, we do—up to 15 uses of the textile parts and 10 uses of the metal parts, such as the mortar. We started out with a reusable main chute but it was heavy with all the extra beef designed into it. So we made it a single use chute and knocked 40 lbs out of the design. Later we saw that the chutes still looked new after a single use and the cost of replacement chutes had gone up significantly. So we ran a lot of tests on materials and determined we could safely reuse the hardware with adequate controls. Interesting thing is, we added back less than 1 lb—this to cover areas of possible abrasion. And this slight-of-hand saved us about 39 lbs! To date, we have used main chutes up to 7 times and saved a ton of money.

The drag chute has now been used approximately 75 times with satisfactory results. The astronauts love it because it gives an added margin of safety in the difficult process of landing that solid brick. It has also saved untold dollars on brake and tire wear.

We’ve never had a landing emergency where the drag chute was called upon to save the day, but that big red, white, and blue canopy adds color, drama, and action to the scene every time the big bird comes home. And, of course, we keep on banking the dollars saved on those brakes and tires. So here’s to John Young. Too bad he never got to fly it.

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About the author: Chuck joined NAA Columbus Division in 1957 while obtaining an M.S. in Mechanical Engineering at the University of Kentucky. Having worked there on ejection seats and missile recovery, he transferred to the Space Division in 1962 as Engineering Supervisor for the Apollo Earth Landing System. He later became Engineering Manager of Docking, Ordnance, and other Apollo Systems. In 1975 he became Engineering Manager of Shuttle Mechanical Systems. Later he was Chief Program Engineer of the Teal Ruby Program in Seal Beach. Chuck retired in 1987 and has consulted on several programs, including the Space Shuttle Drag Parachute. He lives in Garden Grove, California.
At the outset of the Space Shuttle Program, a Ground Vibration Test of the individual and mated Shuttle elements was included in the overall test and verification planning. The production schedules and availability of the flight Shuttle elements made it desirable to consider sub-scale rather than full-scale vibration testing. The Saturn V one-tenth scale model, for example, was successfully used to provide some satisfactory vibration data but at one-tenth scale it was necessary to simulate some upper stage structure and joints and did not provide the same degree of correlation with theory as desired. There was some consideration given to a one-eighth scale and a one-fifth scale Shuttle model but each had its limitations. The final size selection of a quarter-scale Shuttle model was large enough to permit near replication of all primary structure and joints while meeting the size limitations of the available test facilities.

The design and fabrication of the test article was initiated in mid-1974; the testing began in late 1976 and was concluded in December 1977.

The vibration test program concentrated on the dynamic environment of the mated Shuttle configuration associated with the initial phases of the Shuttle mission profile from lift-off through main engine cut-off. The vibration testing included verification of the dynamic math model of the individual single elements: the External Tank, Solid Rocket Boosters (SRBs) and the Orbiter and the four different Shuttle system assembly configurations:

1.0 Heaviest assembly (included a 500 lb payload in the Orbiter Payload Bay to simulate the maximum 32,000 lb actual payload)
2.0 A lesser weight assembly simulating conditions at a critical boost phase flight time
3.0 Least weight assembly at the end of boost phase
4.0 External Tank tilted at 13 degrees to simulate post SRB separation

Three pairs of SRBs were created to simulate three different configurations: one pair was completely filled simulating lift-off, a second set simulated the propellant level at max Q and a third set simulated the SRB empty condition at burn-out. The External Tank Oxidizer was simulated using deionized water with the level adjusted according to the mission phase being simulated. The liquid hydrogen fuel quantity was considered small enough to be omitted from the model for test purposes.

In order for the model to be representative, full replication (exact scaling to the 1/4 of actual dimensions) and near replication, which allowed for some minor simplifications for cost savings, were implemented. Near replication was permitted where the overall elastic stiffness characteristics would not be compromised. Careful attention was given to joint design and the use of alternate materials that were selected for their stiffness similarity and ease of fabrication. The design, fabrication and assembly was accomplished by the Los Angeles Division Model Shop with approximately 90% of the machined detail parts and subassemblies subcontracted to various aerospace manufacturers. Once completed, the entire assembly measured 46 feet from the bottom of the SRB boosters to the tip of the External Tank and 19.5 feet wide Orbiter wing-tip to wing-tip. The weight of the entire assembly simulating the lift-off configuration was 62,853 lbs.

The test fixture was assembled in the Bldg 288 High-Bay in Downey and consisted of an open, rectangular, bolted steel framework 56 feet high, 30 feet wide and 26 feet deep anchored to the facility floor concrete slab. Ten vibration tests were performed in the facility simulating various Shuttle Element and Assembly configurations and ascent flight phases.

The quarter-scale Shuttle dynamic test program met its objectives of providing verification of predicted dynamic response characteristics early in the Shuttle effort. The data obtained from the dynamic tests had verified the math modeling techniques for predicting modes and frequencies of various Shuttle configurations. The program confirmed the benefits of the use of dynamic scale models to verify math models and assist in the analysis of vibration environments of future space flight launch vehicles.
Ultimately, the quarter-scale vibration test data was enhanced by additional vibration testing performed during the Full Scale Mated Vehicle Ground Vibration Test Program conducted at the Marshall Space Flight Center beginning in late 1978 and ending in March 1979. For these tests, the Shuttle Orbiter Enterprise, having completed its Approach and Landing Test Program at Dryden Flight Research Center, was ferried to MSFC on March 13, 1978 and mated to an External Tank and Solid Rocket Boosters. The objective for these tests was to evaluate the mated configurations’ critical structural dynamic response modes which were then assessed against analytical math models used to design the various element interfaces.

Subsequent to the completion of all testing required to support the Space Shuttle Program, the Shuttle Quarter-Scale Assembly was retired as a test article and downgraded to its status as a museum display artifact. The External Tank and all three of the SRB configurations were shipped to NASA JSC and are currently stored there. The Orbiter element was provided to Canada’s SpacePort Museum in Calgary for display on a 10-year loan basis which expires in 2010 and is currently suspended from the ceiling of the Calgary International Airport. The National Air and Space Museum of the Smithsonian Institution intends to have the External Tank and SRB elements eventually transferred from JSC to its facility in Washington, D.C. They are destined for possible future display as a complete Shuttle Assembly once the loan period of the Orbiter for the SpacePort Museum expires. There is a possibility that Downey might be the eventual home for this incredible model if certain conditions are met. Dr. Neal, Space History Curator at the National Air and Space Museum, stated “…please be assured that future display of the model at Downey may be possible when (a) the artifact is transferred to NASM custody and (b) you have a museum-like facility open to the public. As the original home of the orbiters, Downey is certainly an appropriate location for Shuttle artifacts.”

In the meantime, the SpacePort Museum is also considering the possibility of requesting an extension of its loan for the Orbiter element.

The Quarter-Scale Model was an incredible engineering feat and its temporary stay in Downey during dynamic testing certainly adds to the rich history of major space achievements that this site has witnessed over many decades.

Acknowledgements:
1.0 Technical information was obtained from a paper written by D.H. Emero, Project Manager, Shuttle System Project Engineering, Integration and Operations Division. The paper “Quarter-Scale Space Shuttle Design, Fabrication, and Test”, was published in the Journal of Spacecraft and Rockets, 1980, 0022-4650 vol. 17, no. 4 (303-310)
2.0 NASA-JSC and Museum information were provided by the following:
   2.1 Julie Kramer-White, NASA Chief Engineer, Crew Exploration Vehicle Project
   2.2 Dr. Valerie Neal, Space History Curator at the National Air and Space Museum of the Smithsonian Institution in Washington, D.C.
   2.3 Kim Sinclair, Commercial Properties Coordinator, Calgary Airport Authority

About the Author: Stan joined NAA in 1963 as a Propulsion Systems Engineer on Apollo working on the SM RCS Rocket Engine Program. After Apollo, he continued that assignment on the Skylab SM RCS and later did the same work for the Apollo-Soyuz Test Project. He started working in the Propulsion and Power Systems group on the Space Shuttle Orbiter Program in 1973 and continues in that task today. Stan resides in Diamond Bar, California with his charming wife Elke.
Editor’s Note: We asked Lowell to comment on the superb article by Christopher Shores about the original P-51s sent to Britain during World War II. His commentary regarding how the Mustang came about resulted in this splendid article on the origins of that famous airplane. All photos are from the author’s collection.

The Mustang airplane was a wonderful addition to the military inventory of World War II. According to Hap Arnold, it appeared just in the nick of time to allow the air war against the Axis powers to continue. Writings about its origin have been carbon copied from books to articles and few have come close to portraying the actual birthright of the legendary escort fighter which owes much of its conception to Dr. Clark B. Millikan of the Guggenheim Aeronautical Laboratory, California Institute of Technology based in Pasadena, California.

As 1937 drew to a close, James H. Kindelberger, better known as “Dutch”, reflected back on the success of North American Aviation, Inc. since the move to the West Coast from Dundalk, Maryland, in 1935. A relatively new competitor in the aviation industry, NAA was fortunate to meet with good success in capturing new business and forging new relationships within the military establishment. One of these key figures was General Hap Arnold. Hap made a point of maintaining close association with the manufacturing industry that supported the Army Air Corps and drew on the talents of their organizations to provide technical advice outside the Material Command at Wright Field.

Other contacts, from the 1936 Air Races at Mines Field (now Los Angeles International Airport), would prove invaluable over the next several years. Ernst Udet, who performed his famous act of picking a scarf up from the runway with a wing tip, had toured the NAA facility and had extended an invitation to Kindelberger to visit him in Germany should he ever travel to Europe. The French Test Pilot, Michael Detroyat, who piloted the Caudron racer to victory at the race and housed his sleek craft in the NAA plant, would be a return visitor as part of the French delegation assessing America’s aircraft production facilities. He would interact with Ed Horkey on a subsequent visit, providing information on quantitative testing of airplanes.

Though a pursuit project had been on Dutch Kindelberger’s mind, he had reservations about entering that field of competition. Curtiss Wright was well entrenched as a major supplier of pursuit type aircraft for both the Army and the Navy. This prevailing reputation made competition on the home front a very risky proposition. An export pursuit airplane seemed to be a more lucrative undertaking, but the design would be limited by export controls, especially if the performance of the export product met or exceeded the performance of existing aircraft in the U.S. arsenal. Not only was the export of the airframe tightly controlled, but the power plant would have to be approved separately.

Ernie Breech, of the General Motors Board of Directors, had urged Kindelberger to enter the pursuit competition field several times since the company had become a manufacturing corporation on January 1, 1935. This suggestion was pursued in earnest that year as NAA entered the two place pursuit competition with an airplane designed around an Allison V-1710 engine, an engine which would not be test flown for another year. This proposal has been addressed in a previous issue of NAAR News as the P-198 design or XP two-place fighter designed by Lee Atwood. This design went into storage with the cancellation of the Air Corps requirement for a two-place pursuit.

Following in the footsteps of the P-198 design, a study for an export pursuit was launched on February 3, 1938, as scratch notes were prepared for the modification of trainer aircraft parts and assemblies into a single place pursuit for export. With this effort, the groundwork was laid for the development of the NA-50, NA-50A, and NA-53 “Super P-64” export pursuit later that year. At this time, the British Spitfire had already flown and had been introduced in a public viewing.

Hap Arnold had received reports from individuals traveling in Europe, such as Eddie Rickenbacker, regarding the buildup and advancements of air power in Germany and was well aware of the implications. A request was initiated, in February 1938, by his office for a comparison study between American and foreign aircraft. With this effort, the groundwork was laid for the development of the NA-50, NA-50A, and NA-53 “Super P-64” export pursuit later that year. At this time, the British Spitfire had already flown and had been introduced in a public viewing.

Hap Arnold had received reports from individuals traveling in Europe, such as Eddie Rickenbacker, regarding the buildup and advancements of air power in Germany and was well aware of the implications. A request was initiated, in February 1938, by his office for a comparison study between American and foreign aircraft. However, in addition to this request, he tasked North American Aviation, Inc. to provide a study that would
best depict the next generation pursuit airplane. Support for this later request would be difficult for NAA to muster due to the heavy workload on hand. Kindelberger explained this to Hap Arnold in his letter of March 29, 1938:

“In order to do the job properly, finding that our gang was pretty well tied up on other work and that I did not have just the person to do the job the way I wanted it done, I have hired Dr. Clark Millikan of California Institute of Technology to do some work for me on this subject.”

In this same letter he responded to the request for a comparison of U.S. and foreign aircraft, which indicated that the Curtiss Hawk P-37 would be comparable to the Spitfire.

On April 15, 1938, Kindelberger sent a letter of transmittal to Hap Arnold, which included a copy of the Millikan Report, and expanded on his comparison of U.S. and foreign aircraft.

He also explained:

“I was very fortunate last week in having the opportunity to discuss the Messerschmitt with a top-notch German engineer, who happens to be the brother-in-law of Messerschmitt.”

This German engineer was Prof. Dr.-Eng. George Madlung, who was married to Willy Messerschmitt’s sister Ello. Kindelberger then went on to explain the information he had passed on to Dr. Millikan in order for him to prepare the accompanying report:

“The specifications were: landing speed = 70 mph, power = 1,150 hp at 16,500 ft (this was to duplicate the power and altitude of the engine in the Supermarine “Spitfire”), the ship to be as small as possible, cleaner than possible, and to have no external armament or radio, and to weigh 6,000 lbs.”

The fuselage overall width of 40 inches and overall height of 60 inches referenced in the report are not mentioned in his letter. Based on Kindelberger’s instructions, Dr. Millikan’s report described in optimistic aerodynamic terms, an airplane capable of traveling at 391 mph, or reduced to 377 mph for the most optimistic type of service plane. The most comparable engine in America to that of the Spitfire was the 1,000-hp Allison.

In his report, Dr. Millikan made mention of another system feature that is not mentioned in Kindelberger’s letter, the cooling system drag. Dr. Millikan stated that the calculated cooling drag:

“...could be reduced perhaps by 50% if the radiators were located entirely inside the wing or fuselage and a carefully designed ducting system used to lead the air to and away from them. However, no such installations have as yet been reported, and they would be especially difficult to work out in such a small airplane.”

All indications are that Dr. Millikan was working solely from Kindelberger’s brief specifications to produce the report that he had commissioned. Oliver Echols of Material Command was sent a copy of the Millikan report simultaneously with the copy to Hap Arnold. Other key personnel in the Army Air Corps Material Command including Lt. Ben Kelsey, head of fighter procurement, would not be sent a copy of the Millikan Report from NAA until after Kindelberger departed for Europe in late May 1938, as mentioned in his April 15th letter to Hap Arnold. The responsibility for this flow down would rest with Lee Atwood, Kindelberger’s second in command.

In the background of this and other ongoing work, the Allison Engine Division of General Motors had been continually updating NAA, a sister company in the GM stable, with progress reports and technical changes on their V-1710 engine, which at that point, was the engine of choice for the Idealized 1938 Pursuit. The data from Allison was distributed to Chief Engineer Ray Rice, Chief Designer Edgar Schmued, Power Plant Chief John Young and C. T. Torresen of the Standards Department.

On May 6, 1938, the Army Air Corps Material Command issued E.S.M.R. Serial Number P-51-643, a request for comments on an airplane, whose specifications were given in detail, designed around an Allison V-1710 engine with a built in supercharger, as depicted on Material Command drawing Number P38M960. (Authors note: This drawing has not been found in any of the national repositories.) Far too detailed to include here, the design data contained in this E.S.M.R. closely resembled a product derived from the Millikan Report, right down to the extremely clean exterior, the cooling system housed within the fuselage and the 10-foot, 3-inch diameter 3-bladed automatic pitch constant speed propeller. The gross weight was listed at 5,385 pounds, the design altitude as 15,000 feet, high speed at design altitude was 358 mph, wingspan is 32 ft, 6 in. and the overall length is 24 ft, 9-1/2 in. The length was revised to 26 ft, 10-1/2 in. in a penciled note by NAA. Analysis of this report would fail to Edgar Schmued in Preliminary Design where a study had begun in secret on an Allison powered pursuit.

With the increase in workload, and not having an Aerodynamics Department as such, Kindelberger realized this placed a heavy burden on the other members of Engineering to fill this gap. He approached Dr. Clark Millikan at Caltech to recommend a potential soon-to-graduate student to fill the job. The student selected was Ed Horkey, who had been working his way through college in NAA’s transportation department. Horkey was hired upon receipt of his diploma in June 1938 and given a desk in the Preliminary Design office with Edgar Schmued. Horkey’s contributions as an aerodynamicist would prove him to be a valuable asset on many NAA projects.

With his commitment to Hap Arnold behind him, Kindelberger and a representative from Export Sales set off on their scheduled trip, leaving the factory business in the hands of Lee Atwood. After the landing in England, they were toured throughout the British aircraft industry, which included the production facilities for the Supermarine Spitfire. Kindelberger noted that multiple wing assembly lines were required to support one fuselage assembly line, largely due to the complicated elliptical wing structure used on the Spitfire. Following the British tours and formalities, Kindelberger departed England for Germany, leaving the Export Sales representative behind to finalize a contract for the Harvard trainer aircraft.
Once in Germany, Kindelberger became the personal guest of Ernst Udet, on an invitation which Udet extended to him at the 1936 air races in Los Angeles. Udet, who that same year had been placed in command of the Reich Air Ministry’s development section, gave his guest from America the “cook’s tour” of the German aircraft industry. Commenting on the efficiency of the assembly lines, Kindelberger was told by Udet that this had been learned from America. Another American would soon follow in Kindelberger’s footsteps through the German factories. Charles Lindbergh was touring Europe on a factfinding mission for Hap Arnold. He would enter Germany through Belgium shortly after Kindelberger returned to England.

While Kindelberger had been in Germany, the British had decided to place a sizeable order for Harvard trainers and the legal documents awaited his signature when he returned to England. The British had, a short time before, announced that they were going to expand their air programs, but their production capabilities were limited. Following his return to Britain, Kindelberger was approached about building Spitfires to supplement British production. This, he declined based on the complicated wing design and the existing workload already in the NAA factory. In subsequent conversation, he was made aware that a next generation fighter was being planned as a replacement for the Spitfire and that the Operational Requirement, OR.73, would soon be issued. The requirement OR.73 called for an airplane whose data was fairly well in line with the data contained in the Millikan Report. The Martin Baker MB.3 designed to this requirement would not fly until March 3, 1942. Prior to his departure from England, the British suggested to Kindelberger that NAA design and build a new fighter of its own.

While Kindelberger and Brophy were away, Allison Engine Division had provided the latest updates on their V-1710-F1 and F2 engines to NAA's Chief Engineer, Ray Rice, including a note that a change order was going through to permit the use of liquid-cooled engines in place of air-cooled as equivalent engines. Heretofore, liquid-cooled engines were not allowed for use in pursuit aircraft, and this predicted change would allow airframe designs with greatly reduced frontal area. Along with this development, the pursuit that had been developed out of trainer parts went into production on August 1, 1938 as General Order NA-50, on a contract with Peru.

As Kindelberger and Brophy were returning home from England; a more powerful version of the NA-50, utilizing the R-1830-53C-G engine, was started. The NA-50A (NA-53 Super P-64), was a re-engined NA-50, whose characteristics made it highly competitive with the Curtiss Hawk. Under the current export controls this would make the NA-53 ineligible for export. Another NA-50A variant would become the NA-68, built under contract for Siam and, after confiscation by the U.S. Army Air Corps, would be known as the P-64.

In Germany, the Munich Conference, held on September 29, 1938, had ended with Hitler gaining concessions which would increase political tension across Europe as his buildup for conquest continued. Kindelberger and Brophy would return to NAA to find multiple pursuit projects in work, the NA-50, NA-50A and the NA-53, along with the secret Allison powered pursuit study making slow headway in the background. The information they brought from Europe drove a thorough review of all pursuit business on hand. Work was proceeding on the NA-50 contract for Peru. At least nine versions under the NA-50A General Order developed from trainer airframes were studied in the 1937-1938 period.

On January 5, 1939, the British formally issued high-speed single-seat fighter specification F.18/39, Operational Requirement OR.73, as a replacement for their Hurricane and Spitfire fighters. The NA-53 project was cancelled by an order from Lee Atwood on February 3, 1939, the engine on loan for this project was shipped to the Douglas plant for use there and all NA-50 common parts were returned to stock. At approximately this same time, Atwood had become aware of a report out of Britain, RAE 1683, dated August 1935, regarding the cowling and cooling of radiators in such a manner as to actually nullify much of the radiator drag and possibly produce thrust from the exhausted air. This minimum pressure drop effect would come to be coined “The Meredith Effect” after the author of the theory.

The Meredith report was later improved upon by R. S. Capon of the R.A.E. as RM 1702 and published in March 1936. An improved study by Gothert on the subject was published in Germany. This document, dated September 10, 1938, was subsequently adopted and published by NACA as TM 896. This later report, NACA TM 896, would be the one Ed Horkey, in conjunction with Irving Ashkenas and Joe Beerer, used to develop the cooling system for the Mustang airplane.

In its eyes, the Army Air Corps considered NAA as an excellent provider of trainer, observation and medium bomber aircraft. Therefore, when they issued Circular Proposal CP39-770 for the 1939 pursuit proposal competition on March 11, 1939, North American was not asked to submit a design for competition. Instead, NAA was asked to comment on the circular proposal.

CP39-770 offered two liquid-cooled power plants as alternatives to the usual radial engines seen in previous circular
proposals. One was the Pratt & Whitney X-1800 flat engine, the other was the Allison V-1710 of 1,150 hp. Edgar Schmued commented back regarding a Material Command design incorporating each of these two engines. His main criticism was directed at the fuel load, which was felt to be too restricted, based on the calculated performance of the airplane. He suggested adding external fuel tanks, which was contrary to operational policy, to increase the operational range instead of carrying the fuel internally. He also recommended changes in armament locations, from the engine compartment to the wings outside the propeller arc. Another important factor was the cooling system, on which he commented:

"Due to the small size of the engine compartment, the oil radiator, coolant tank and cooling radiator will have to be placed in the fuselage to the rear of the pilot."

These comments were submitted to the Chief Engineer, Raymond Rice, for review and transmittal to the Army Air Corps shortly after May 17, 1939. That ended NAA's involvement in the Army Air Corps pursuit competition for 1939.

By June 1939, Edgar Schmued had made good progress on the preliminary design for the Allison powered pursuit which resulted from the Millikan Report. Two members of the British Air Commission, H. C. B. Thomas and Charles Luttman, visited NAA and received a progress review on the Allison powered pursuit, or rather, the Company Sponsored Pursuit.

It was shortly after this visit that NAA launched a secondary effort to produce the NA-53 as an export fighter to support the French and British needs following the fall of Poland. Work on this project was engaged with issuance of Specification 1405-A on October 27, 1939. This proposal went through several iterations presenting the NA-53 with six different engines and terminating as Specification 1533 on December 8, 1939. The death knell had been sounded for the NA-53.

On this same day, the finishing touches had been completed on a tentative specification for the Allison-powered Company Sponsored Pursuit which was issued to complement the design drawing package that Ed Schmued had been preparing. This design was ready for presentation to the British and the French. Kindelberger and Atwood traveled to New York and met with representatives of the British Air Ministry, with the purpose of selling them on the P-500 design. The presentation was a dismal failure and ended with the British insisting that NAA build the P-40 under license from Curtiss. Atwood, quite familiar with the P-509 design that was fermenting back at the plant, requested another meeting on February 6th in which he sketched out the general arrangement of the P-509 Allison engine pursuit. However, without a proper proposal, the effort was futile and the British pressed forward with their demand that NAA build the P-40. At this point, Kindelberger returned to the factory in California, leaving Atwood to continue working with the British on a favorable solution to the problem.

NAA's Aerodynamicist, Ed Horkey summed up the situation:

"We had a meeting in the War Room on the second floor of the Admin Building. Here we reviewed the pursuit design and formulated a plan to move the proposal ahead without delay."

The P-509 design was revised by Ed Schmued, relocating the radiator duct forward of its original position. The drawings were then turned over to Al Algier for final formatting. On March 5, 1940, Kindelberger notified Ernie Breech that “the big foreign deal has blown up and he is rushing to New York to keep in touch with the situation”. On March 6th, a counter proposal was sent to the British stating that NAA would build a plane of its own design that would be better than the P-40. On March 11, 1940, the P-509 proposal package, consisting of three drawings and the preliminary design data Specifica-
tion 1592 were airmailed to NAA’s New York Headquarters at Essex House. Ed Horkey’s aerodynamics report, “The High Speed of the Allison Powered Pursuit”, which completed the proposal, would follow on March 18th.

By March 15th, positive progress had been made and confidence was high enough for Research and Development Order SC-1050 to be issued for studies to proceed on the Allison engine pursuit design and for the construction of a mockup. Lee was still hard at work reassuring the British that the P-509 design would be a sure winner and incorporate the British cooling system technology theorized by Meredith. Meanwhile, Ed Horkey of NAA’s Aerodynamics Department had initiated wind tunnel tests of a wing section with armament in support of the impending pursuit project.

At the insistence of Sir Henry Self, NAA was instructed to procure data from Curtiss Wright to support the production of NAA’s fighter project and to support the production of P-40 airplanes should NAA’s design fail. On April 10, 1940, the day that Hitler launched his invasion of Denmark and Norway, Lee Atwood traveled to the Curtiss Wright facilities in Buffalo, New York to negotiate with Burdett Wright for documentation on the P-40. The meeting was set for April 11th. At this point, Burdett Wright became fully aware that NAA’s proposed design had become a competitor with the XP-46. The XP-46 had been proposed as the replacement for the P-40 and plans were afloat to make the plane available for foreign sale. Burdett Wright agreed to provide data to NAA at a price that would partially compensate his company for the development of the XP-46. The sum agreed upon as a result of this meeting was $56,000.00. An attempt was made by Wright to recover the remainder of the XP-46 development costs from the Army Air Corps, which met with failure based on the design being declared a corporate venture by the Army Air Corps.

This business out of the way, Atwood returned to New York where he received a letter contract for 400 NA-50B pursuits to NAA Spec 1592. Burdett Wright prepared a list of documents on April 17, “Various items of data which might be of interest or value to North American”. Included with this list was a page entitled “For discussion of development costs to be met, in part, by North American in building a new pursuit for the Anglo-French”. However, the document package of items selected from the list would not arrive at NAA until May 14, 1940, well after the baseline design for the NA-73 airplane had been established. An attempt by Curtiss to extract royalties from NAA was foiled, since the NA-73 airplane, soon to become known as the “Mustang” was unique to North American Aviation, Inc.

On April 14, 1940, Lee Atwood issued General Order NA-73 for the construction of one Allison powered single engine pursuit airplane, including all charges accumulated on General Order SC-1050 to be transferred to this order.

There was one more hurdle for the new pursuit to clear. The export license agreement with the Army Air Corps had been submitted but not approved. It was being withheld pending a report on the legalities of exporting an advanced fighter to belligerent nations, strictly forbidden previously by presidential order. When Hap Arnold was made aware of the situation, he stated that it was, “Probably just another of Dutch’s South American trainers”. On April 25, 1940, all such restrictions were lifted, paving the way for unlimited sale of the latest models of American warplanes to France and Great Britain.

After the introduction of the Packard-built Rolls-Royce Merlin engine, the Mustang became a truly magnificent performer – escorting bombers on long-range missions in both the European and Pacific Theaters. Edgar Schmued’s second-degree curve method of design provided an exceptionally clean, flush riveted fuselage that housed Lee Atwood’s much pampered minimum pressure drop cooling system. Ed Horkey’s laminar flow wing limited the effects of compressibility and saved many pilots from certain disaster in combat. Ralph Ruud’s highly efficient production line enabled an exceptionally high production rate. Above all this was James H. “Dutch” Kindelberger whose management skills solidified efforts to produce one of the greatest fighter aircraft of World War II.

About the Author: Lowell hails from Ocean Springs, Mississippi, just a few miles east of Keesler AFB which accounted for many AT-6 and B-25 flights over his home. He developed an early interest in aviation and began flying forward swept wing model gliders in 1949 while still in grade school. He moved to California in 1962 and joined NAA as a Blue Print Folder and Trimmer. Except for a four-year stint in the military, he continued working until he retired from Boeing North American in 2003. An avid P-51 historian, he currently resides in Torrance, California with his charming wife, Linda.
NAAR – Summer 2009

North American Aviation Awards at the U.S. Air Force Academy
by Edmund Rusinek

After a series of very amicable exchanges with the NAA Retirees Bulletin, the United States Air Force Academy has agreed to create three departmental awards in the name of North American Aviation to be awarded each year, starting in 2010, in perpetuity. These awards will be presented to the outstanding graduating cadets in the fields of aeronautics and astronautics. Usually presented in the name of outstanding individuals, having these named after our company will memorialize the name North American Aviation long after we are all gone! Each department at the academy chose its own title for the award, so each is different; however, the intent is the same:

- **NAA Award for Excellence in Applied Aeronautics Research**
- **NAA Award for Outstanding Cadet in Aerodynamics**
- **NAA Award for Outstanding Achievement in Selected Astronautic Courses**

In addition, the NAA Retirees Bulletin will sponsor the Outstanding Cadet Candidate Award at the Academy Prep School. This award will recognize the Prep School student who has demonstrated excellence in all phases of the Prep School Program. The student must:

- Possess a superior scholastic record as evidence by GPA and test scores
- Be outstanding in all phases of the Military Training Program
- Be outstanding in all phases of the Athletic Program
- Be outstanding in all phases of the Character Development Program
- Exemplify a highly positive character, personality and potential for success at the Academy and in the USAF

As requested, this award will be named in honor of North American Aviation Inc. The NAA Retirees Bulletin volunteer staff could not think of a better organization to be associated with than an institution involving the education of young people in the fields of science who are dedicated to the military service of their country.

Many years ago, when Bill Halpin of Las Vegas, Nevada sent the Bulletin a check for $500.00, in addition to his $100.00 Silver Eagle subscription, to be used as needed; the donation was used to start a contingency fund. Over the years, other retirees sent extra dollars for “office emergencies and coffee”. Since the Bulletin has no office, no hired staff and no “koffee klatches” (come to think of it, all we have are five terrific volunteers with loving care for NAA); all these monies went into the fund. This project cost thousands of dollars and we are grateful to Bill and all the others that so graciously thought of us when they sent in their renewals. Without those contributions, this sponsorship would not have been possible. It is this kind of attitude and spirit that has always made North American Aviation the Premier Company that it was! 🌟

Contrails From The Past
by Ed Rusinek

Dear Ed,

The Allison-Engined Mustang article in the Spring 2009 Issue of the Bulletin is absolutely fabulous. There are several aviation history buffs in the Nevada Wing of the Commemorative Air Force, who, I know, will be delighted in reading my copy of this extensively detailed article on the early P-51s.

—Frank Pelton, Las Vegas, NV

Ed’s Ans.: Don’t keep your friends waiting, Frank. Convince them to subscribe to the NAAR Bulletin and to get their own copy with the P-51 cutaway centerfold and we will even throw in the Winter 2008 Issue as an extra bonus.

Dear Ed,

Seventy years ago, in March 1939, I was hired by NAA in Inglewood to manufacture detailed parts. The starting pay was 40¢ per hour. I started on 2nd Shift so I received a 3¢ bonus and my rate came up to 43¢ per hour.

I was in Supervision for 25 years. In 1942, we organized a Foreman’s Club and forty of us signed the Charter. It later became the Management Club. I am the only charter member remaining. I retired in 1981.

—Gene Hales, Stuart, OK

Ed’s Ans.: Thank you, Gene, for this brief insight of the company during the early years. You folks did a splendid job of making NAA the best company with the finest people!

Congratulations and Best Wishes to

Gerald and Esther Funk of Paonia, Colorado celebrating their 66th Wedding Anniversary
William and Betty Anderson of Edmonds, Washington celebrating their 64th Wedding Anniversary
John and Rachel Koblosh of Redondo Beach, California celebrating their 60th Wedding Anniversary
William and Geraldine Jones of Menifee, California celebrating their 60th Wedding Anniversary
Irwin and Shirley Altnue of La Mirada, California celebrating their 58th Wedding Anniversary
John and Jo Tranchina of Mesa, Arizona celebrating their 41st Wedding Anniversary

To get the full value of a joy, you must have somebody to share it with.

—Mark Twain
CARTER, ROBERT L., 81 – passed away in Salinas, CA on September 6, 2008. He attended Yale University and graduated from the U.S.A.F. flying school in January 1944. He flew P-40s in the Aleutian Islands in 1944-45, continued his military flying in P-51 and P-80 aircraft and joined the 4th Fighter Group at Andrews AFB in 1948-49 where he was a member of the Aerobatic Team and the USAF Champion Gunnery Team and the Silver Sabres Aerobatic Team, in which he flew in the slot position and solo formations. He went to Korea with the 4th Fighter Group’s first F-86As and shot down a MiG-15 during the first large scale jet air-to-air dogfight on December 22, 1950 (readers will recall his article, “That Afternoon Over the Yalu”, in the Winter 2005 Issue of the NAARB). Joining NAA in 1952 as a test pilot, he did extensive testing on the redesigned F-100A after the death of Chief Test Pilot George Welch. Other aircraft he flew were the F-86D, E, F, and H; the F-100A, C, D, and F; the F-107, and the T-39 Sabreliner. He later became the NAA Corporate Representative at NASA JSC, KSC, and Washington, D.C. He retired in 1982 with 30 years of Service. J.O. was a good friend of the Bulletin and he will be sadly missed.

ADAMS, LAWRENCE “LARRY”, 84 – passed away peacefully on March 27, 2009 from undisclosed causes. Larry worked for NAA/RI for 35 years and retired in 1987. He is survived by his brother and extended family.

CANNON, EDWARD J., 83 – died on May 16, 2009 of undisclosed causes. He was a Director of Contract Pricing at NAA/RI and was a member the Rockwell Management Club. Ed was a truly distinguished and valued Contracts/Pricing executive. He and his contemporaries lead the way on many landmark and innovative cost estimating/pricing methods considered essential to be profitable and successful in the industry. He was held in high esteem; a man of honor, integrity and warmth who left this world a better place.

CARTER, ROBERT L., 81 – passed away at his home in Fletcher, NC in November 2008. Bob was an engineering group leader at the Columbus Division Human Factors unit from 1956 to 1967. Under his direction, the automatic rocket powered ejection seat systems for dual and tandem crews were developed for the A3J and OV-10A.

CASTLE, PHILIP V., 91 – passed away on May 12, 2009 from undisclosed causes. After completing graduate work at UCLA he began a career with NAA/RI as a Systems Analyst, retiring in 1979. He was preceded by his wife of 58 years, Lillian.

COVER, JOHN H., JR., 88 – passed away on February 7, 2009. He earned a Ph.D. in Physics from the University of Chicago and was part of the NAA team that won the Apollo project. He invented the Nonlethal Taser Weapon. He is survived by his wife Ginny.

DICKSON, DONALD L., 82 – died in Orange, CA on January 14, 2009 of cardiac arrest. Bob served in Manufacturing for 36 years until he retired from the B-1 Division in 1986.

ROBERTS, JAMES O., “J.O.”, 84 – passed away in Salinas, CA on March 10, 2009 after a four-year battle with Alzheimer’s disease. Graduating from Ohio State University, he joined NAA/Columbus as an electrical engineer and was involved in all Columbus developed aircraft and the B-1A/B. Karl was a member of the American Rocket Society, the Ohio Academy of Science and MENSA. He retired in 1989 with 33 years of service.

FROST, LOUIS E., 82 – of Laguna Hills, CA passed away on March 17, 2009 from undisclosed causes. Lou joined NAA in 1946 and became the NAA/RI Manufacturing Engineering Specialist for the aerospace industry association; disseminating technical information to all areas and divisions of the company. He was involved with many major projects expanding the manufacturing expertise of the corporation. He retired in 1978. He is survived by his wife of 67 years, Grace.

GEHRKE, RICHARD J., 85 – died on March 9, 2009 in Fullerton, CA. Dick served for many years at the Autonetics facilities. He later retired from Hughes Aircraft in 1991. He is preceded in death by his wife, Geraldine, and son, Bruce.

GOULD, LANE E., 86 – of Kelseyville, CA passed away on May 6, 2009. He served in naval aviation during World War II and continued his aviation career at Convair before joining NAA/RI. He retired at the Palmdale facility in 1985. Lane is survived by his wife, Lummie.

HANN, MILFORD R., JR., 71 – obituary indicated death occurred on April 20, 2009. He had served proudly in the Navy before he joining NAA/RI. He is survived by his loving wife, Rose.

HAUENSTEIN, CLIFFORD A., 75 – passed away at home in Moorpark, CA on December 17, 2008. Cliff started in the experimental engine unit, working on specialized start systems, at Rocketdyne in 1955. He then progressed through several leadership positions as Project Engineer on the Apollo Command Module ACS, Attitude Control System, and LM Ascent Engine and as Program Manager on the PK Stage IV, Peace Keeper, and Program Manager for IRAD, Independent Research & Development. He is survived by his wife Ruth.

HERM, LEO M., 93 – a resident of Anaheim, CA died on March 15, 2009. Leo was an electrical engineer at Space Division where he served on several programs before retiring in 1976 after 34 years of service. He is survived by his wife of 60 years, Gladys.

KAWANA, HARRY, 79 – of Gardena, CA died on September 30, 2008 after suffering several heart attacks. Harry joined the Flight Control Group at NAA/LAD after receiving an M.S.A.E. from USC. He received several awards for his work on the F-100, F-117, B-1, and the Space Shuttle. He retired in 1986 after 32 years of service. He is survived by his wife, Mieko.

KEAS, WARDEN F., 84 – passed away on December 2, 2008 in Torrance, CA after a valiant battle with cancer, open heart surgery and a hip replacement. He joined LAD as an electrical engineer in 1951 after graduating from Kansas State University and retired with 40 years of service. An accomplished engineer, his other passion was being a clown. He attended Clown College in Lacrosse, Wisconsin and won many awards at clown conventions. He used his talent to bring laughter to schools and retirement homes. He is survived by his wife Shirley.
KIKENDALL, LLOYD C., 87 – of Las Vegas, NV passed away on January 22, 2009. Lloyd retired from LAD in 1979 after 32 years of service as a facilities engineer. He continued as a consultant for ten more years. He is survived by his loving wife Geraldine.

LAXTON, EUGENE F., 81 – passed away on Saturday, February 28, 2009 in Torrance, CA due to complications from pancreatic cancer. Eugene had a distinguished career as an aerospace engineer for 35 years. He worked for many companies including NAA/RI and eventually retired from Boeing in 1993. He was part of the B-1 design team which was awarded the R. J. Collier Trophy in 1977 for outstanding achievement in Aeronautics. His wife of 57 years, Cecilia preceded him in death.

MACIAS, VERA L., 83 – died peacefully in April 2009 at her home in Tustin, CA surrounded by her family. Vera worked as an administrative secretary at NAA/RI for 10 years before she retired.

McCLANAHAN, CONNIE B., – of Temecula, CA died on February 25, 2009 of complications following surgery. She served for 35 years at NAA as a mechanic, retiring in 1987. Connie worked on the T-39 Sabreliner, the B-1, and the Space Shuttle. She is survived by her husband of 42 years, Clifford.

MINNER, CLIFFORD R. “BOB”, 83 – died at home in Missoula, MT. Graduating from high school, Bob joined the Navy and ended up flying missions in the South Pacific as Plane Captain with Patrol Bombing Squadron 106, Crew 19. Getting a degree in biology, he taught science courses at El Camino College in Torrance before moving into flight test engineering. He worked on several aircraft projects including the F-15, B-52, B-70, B-1A, B-1B, and B-2. He managed test programs at the White Sands Test Track, Holloman AFB, Edwards AFB, and the Microwave/Randome Test Facility in Lamont, CA. He retired from LAD in 1986 after 25 years of service. He is survived by his loving wife of 60 years, Madelyn.

MURRAY, MAURICE, 78 – succumbed to prostate cancer during the latter months of 2008. He worked at LAD in Quality Control and Purchasing on multiple programs including the B-1 bomber. He is survived by his wife and an extended family.

NELSON, ELMER O., 90 – passed away peacefully on October 27, 2008 after a long illness. He worked at NAA/RI on all of the NASA Apollo space vehicles. He is survived by his wife of 65 years, Lolita.


ORGILL, JEANETTE R., – died quietly in her sleep at Apache Junction, AZ on February 14, 2008. The information was made available after her name appeared in the “Lost Sheep” section of the Bulletin. Jeanette worked at LAD and the Corporate Offices where she edited the Fortran Volume of the Corporate Computing Manual. She retired in 1973 after 23 years of service.


SILVERMAN, STEVEN L., 55 – passed away at his home in Seal Beach, CA on February 9, 2009. Although born with severe cyanotic heart disease he earned a M.S. degree in Aeronautical Engineering from the University of Virginia. He joined NAA/RI and served for 25 years in Systems Integration. During that time, he managed a full and successful life although he had to endure eight intrathoracic surgeries and a heart transplant. He will be sadly missed by his family, friends, and co-workers.

THOMPSON, EULA “TOMMIE”, 92 – succumbed to congenital heart failure on March 29, 2009 in Goldsboro, NC. She retired from LAD in 1980 after 35 years of service in Quality Control.

THOMPSON, IVAN E. “TOMMY”, 91 – passed away in Glendale, AZ on September 7, 2008. He joined LAD in 1947 in Tooling, later transferred to Rocketdyne where he served as a tooling engineer. He retired in 1977 as Manager of Tooling, Second Shift. He is survived by his wife Ardith.

VANCE, ARMETTA C., 85 – passed away in West Linn, OR as a result of a stroke. She had retired from the B-1 program at LAD in 1986 after 29 years of service including prior assignments at Autonetics, Space, and Seal Beach. Never allowing herself to grow old, her passion was riding on a Harley-Davidson motorcycle.

WATANABE, HIDEO, 80 – passed away on February 17, 2009. A resident of Santa Monica, CA, he was active in the Management Club when he retired from the B-1 Division after many years of service. He later went on to work on the B-2 program at Northrop-Grumman.

WEINER, FREDERICK, – passed away peacefully on March 12, 2009. Fred worked in aerospace engineering for many years before retiring from LAD in 1984 after 35 years of service. His wife of 53 years, Selma, preceded him in death.

WOLFORD, LILLIAN M., 87 – died peacefully on March 1, 2009 after three years of failing health. She was employed at NAA/RI on two separate occasions during her working years. She was preceded in death by her husband, Leonard, a retired U.S. Marine.

ZEHALA, WILLIAM J., 78 – of Columbus, OH passed away on January 27, 2009. Bill joined NAA at the Columbus facility as a civil engineer after receiving a B.S. degree in Civil Engineering from the University of Pittsburgh in 1953. He retired in 1989 after 28 years of service. He is survived by his wife Betty.

NAAR – Summer 2009

LOST SHEEP—BULLETIN RETURNED WITH NO FORWARDING ADDRESS

J. A. GARCIA – LAS VEGAS, NV

I APOLOGIZE TO MARTIN G. “BUZZ” HOLLAND – In my rush to meet deadlines, I did not check out the late information on the passing of Julius Kany and accepted as fact that he was the last survivor of the original Bald Eagles that trekked across the country from Dundalk, Maryland to Inglewood, California. At the age of 94, Buzz Holland is the last member of that special group and he is very much alive! I am sorry for this dreadful mistake and I wish Buzz many years of good health and happiness!

—Ed Rusinek, Editor
The Hubble Space Telescope is lifted out of the cargo bay of Space Shuttle Atlantis following completion of the final servicing mission for the orbital observatory. The crew of STS-125 performed five spacewalks to replace and repair HST’s batteries, gyros, and cameras to extend the life of the telescope for at least five years. STS-125’s crew—Commander Scott Altman, Pilot Gregory Johnson, Mission Specialists Andrew Fuestel, Michael Good, John Grunsfeld, Michael Massimino, and Megan McArthur—returned to Earth May 24, 2009 after a mission duration of 12 days, 21 hours, and 37 minutes concluding one of the final missions of the Space Shuttle Program before NASA retires the fleet in 2010. To the men and women of the Space Shuttle Team, a job well done!