The P-51's Turbulent Development

By John Fredrickson

The legendary aircraft's designers overcame significant developmental pains creating the iconic fighter.

The iconic P-51 Mustang is rightly regarded as a marvel of engineering, but its path to becoming one of the legendary fighters of World War II was anything but smooth. Its development was beset with serious technical, bureaucratic, and manufacturing complications, but these were each overcome in turn, allowing the fighter to become an icon of World War II.

The program only survived because executives at North American Aviation (NAA) and Army Air Forces chief Gen. Henry H. "Hap" Arnold were convinced of its ultimate potential.

James H. "Dutch" Kindelberger, president of NAA, had strong business ties to European countries under Nazi threat in 1940, stemming from their earlier purchase of trainer airplanes. As German forces advanced on France and England, these nations wanted to know: Could North American build P-40 Warhawk fighter airplanes on license from Curtiss-Wright?

Kindelberger counteroffered to design and build a brand-new airplane that would leapfrog the aging, prewar P-40 design. Engineers at North American had been privately mulling the prospect of a new fighter for months. A deal was struck, but France disappeared into the Third Reich before the new model could be delivered.

No new fighter would have saved France from the Nazis, but a new fighter might give Britain's Royal Air Force a much-needed edge in fending off invasion.

Joining Kindelberger on what would become the Mustang program was Edgar O. Schmued, a talented German-born aircraft designer. He'd served in World War I and then joined General Motor's Brazilian operation during the 1920s. Special arrangements were made for Schmued's immigration to the United States.

Kindelberger and Schmued envisioned an aircraft that would be an agile, sturdy, fast, and lethal fighter with formidable air-to-ground capabilities.

Company records reveal that the design of the new fighter was heavily influenced by a little-known two-seat trainer aircraft labeled NA-35. It first flew only five months before initial design work commenced on NA-73, the internal designation for what would evolve to become the P-51.

The NA-35 was to embody a series of precedents. It was the first North American aircraft to be powered by a liquid-cooled engine, an innovation that yielded a greatly diminished frontal area for the fuselage. Schmued, the chief designer, incorporated a recently invented laminar-flow wing specification. A single sheet of smooth aluminum made up the entire upper wing surface, ensuring minimal drag and a clean airflow.

Freelance pilot Vance Breese deftly handled the maiden flight on Dec. 9, 1939. Breese was one of a number of Southern California test pilots who earned rich

rewards for taking new models aloft for the first time.

Work began on a second NA-35, but the demand for a small trainer was deemed to be tepid. Further work languished in 1940 because other projects at NAA took priority.

FIVE FEET TEN, 140 LBS

Kindelberger informed the board of directors at their July 1940 meeting that he'd abandoned NA-35 and sold the design to Vega for $100,000, where it became the Vega 35. A handful of additional -35s were produced before the resources of Vega were commandeered to produce military airplanes. The Vega 35 remains noteworthy because the diminutive craft, with a mere 150 horsepower, was an essential precursor to the Mustang.

Kindelberger let Schmued handpick his staff for NAA's highest priority project, the new British fighter. The team started laying out the new airplane on May 5, 1940. Kindelberger instructed Schmued to build the new airplane around a pilot five feet 10 inches tall, and weighing 140 pounds, and work out from there. Schmued found such a man already on the payroll, sat him in a chair, and then began calculating the requisite man-machine interfaces.

Schmued possessed ample project management skills to reliably track progress and quickly react to problems as they arose on any aspect of the design. The team devoted themselves to NA-73 and nothing else. Only on Sundays did they wrap up their work early—at 6:00 p.m.—to acknowledge the weekend.

San Diego Air and Space Museum photos

Above left: P-51 designer Edgar Schmued. Above: James Kindelberger, president of North American Aviation. Kindelberger let Schmued handpick his design team for the desperately needed fighter.

DOD photo

P-51s in formation. The highly maneuverable fighter was ideal for escort missions and a match for the Luftwaffe's fighter aircraft.

The new British fighter would benefit from four important design features that would be validated by wind tunnel testing:

•A new laminar-flow wing design would remain efficient even under wartime abuse.

•Elegantly crafted fuselage contours to further minimize drag.

•Low frontal area of the fuselage, made possible by the liquid-cooled engine.

•An innovative engine cooling system placing the radiators behind the pilot, producing the P-51's distinctive air scoops aft of the cockpit and under the fuselage.

By building its own design, NAA could employ the "design-for-production" methodology, ultimately yielding higher production rates at lower unit cost.

American combat aircraft of the World War II era were most frequently powered by radial engines. The pistons were typically arranged in a circle around the propeller shaft, and each was exposed to the oncoming airflow so heat could be dissipated by metal fins, an approach similar to many modern-day motorcycle, chain saw, and rotary lawn mower engines.

The pistons on a liquid-cooled engine, however, were neatly lined up in a row behind the propeller. While rotary engines required wide, drag-inducing "faces" and a broad fuselage, the choice of a liquid-cooled engine allowed a slim, slippery nose design for the P-51.

Heat dissipation is a vital aircraft design consideration. Only about 25 to 30 percent of the energy derived from aviation gasoline becomes shaft horsepower. Placing the radiators (oil and coolant) at the bottom of the fuselage and aft of the pilot proved to be the secret ingredient that yielded a notable performance advantage.

In 1971, at a symposium celebrating the conception and development of the Mustang, Schmued explained that the expansion of the air as it passed through the radiators actually produced additional thrust.

Schmued recalled some problems. For one, none of the established foundries in the Los Angeles area would take on the enormous magnesium landing-gear casting work needed for the new fighter. Only a small shop would accept the challenge. Schmued placed a "watchdog" at the foundry to monitor the work. When the man arrived a few days later at North American with the casting, it was so hot it had burned a hole in the carpet of his car.

There was another problem with the same assembly. On a drawing, an engineer mistakenly specified a steel forging with a diameter of 4.97 rather than 4.997 inches. The part arrived undersized, putting the project behind schedule. The team wracked their brains in search of a solution and ultimately hit on the idea of using chrome plating to salvage the part and preserve the schedule.

There was excessive overtime on the project, but the end result was nothing less than a miracle. The design and shop fabrication of the completed prototype was completed on Sept. 9, 1940, a mere 117 days after project initiation.

Initial versions of the new fighter were to be powered by an Allison engine turning a Curtiss three-bladed propeller. It was best suited for flying at lower altitudes.

The Allison engine arrived late and didn't match the drawings. The wiring harness was positioned such that the motor mounts required rework before the engine could be installed.

After the delays, the prototype NA-73 quickly moved into flight test. Bearing the civil registration of NX19998, it first flew on Oct. 26, 1940. Breese was once again at the controls and recorded another successful first flight in his log book.

Unfortunately, the prototype ingloriously came to rest upside-down in a farmer's bean field on its fifth flight, Nov. 20, 1940. Company test pilot Paul Balfour had been forced down by a fuel-related engine failure. It seemed that a fuel valve had stuck or was never operated. Everybody was wringing their hands at the sight of the broken propeller shaft, scratched windshield, crushed vertical fin, and bent wing. Balfour had to be treated for injuries.

A mobile crane was summoned to retrieve the damaged airplane before sundown. It was decided to wash off the mud, replace all the damaged parts, and try again. Given the magnitude of the damage visible in photographs of the wreck, NA-73X was repaired amazingly quickly. The engine was ready for a test run on Dec. 31, 1940, and the aircraft next flew on Jan. 11, 1941.

North American was convinced at an early date that the Mustang design would be a watershed. Production of 320 Mustangs for the British Royal Air Force began as the company engineers desperately sought solutions to improve the high-altitude speed and performance of the Allison engine. As stipulated in the military aircraft export requirements, two examples (the fourth and 10th units

National Advisory Committee for Aeronautics photo

Photos by Alfred T. Palmer via Library of Congress

Right: A woman works on the landing gear of a Mustang at the NAA facility in Inglewood, Calif., in 1942. Far right: A P-51 under construction at the plant.

Langley Research Center Archives photo

Far left: The XP-51B Mustang in the wind tunnel of NACA's Ames Aeronautical Laboratory in 1943. The unusual fuselage contours, among other things, were validated in wind tunnel testing. Left: Designers work on a P-51 engineering model.

off the assembly line) were redesignated XP-51 and handed over to the Air Corps at Wright Field, Ohio, for evaluation in August and December 1941.

No further orders for the Mustang were immediately forthcoming, though. Kindelberger later lamented, "We thought we had the best airplane in the world and wanted to keep building it—but we didn't get orders."

AN UNWANTED ORPHAN

Air Corps bureaucrats at Materiel Command held the Mustang in disdain and had no intention of evaluating the two test items in their custody. Though their reasons were not set out officially, NAA deduced them as follows:

•NA-73 was undertaken by North American for export. Neither the Army Air Forces Materiel Command at Dayton, Ohio, nor the Santa Monica, Calif., office had requested it. The Mustang was an unwanted orphan that fell into the category of "not invented here."

•North American didn't have the pursuit airplane legacy enjoyed by Bell, Curtiss, and Lockheed. Among the massive production decisions announced on Aug. 16, 1939, it was decreed that the primary wartime role of North American was to be a builder of AT-6 trainers and B-25 medium bombers.

•Conventional wisdom had it that pursuit airplanes with air-cooled radial engines were faster, lighter, simpler, and more nimble than liquid-cooled models. Liquid cooling systems were considered to be burdened with the extra weight of coolant, radiators, air scoops,and all of the associated plumbing.

•The Allison engine limited Mustang operations to lower altitudes. A supercharger would be needed to perform at the higher altitudes where heavy bombers operated. Unfortunately, no such supercharger existed, and if invented, it would ruin the aerodynamics.

•The feared German invasion of England was becoming less likely, thus mitigating the need for a low-altitude fighter.

Some authors have asserted that Maj. Gen. Oliver P. Echols, with power over procurement, was angry with Kindelberger. The Mustang was undertaken contrary to the wishes of Materiel Command, which wanted the company to build the P-40 under license. The theory continues that Echols was on a vindictive quest to punish North American. The Inglewood, Calif., plant was then producing two Mustangs and two B-25s per day, while Echols desired more fast attack bombers and no further pursuit airplanes from North American.

Whatever the cause of procurement officer attitudes, it took the razor-sharp mind of Hap Arnold to slice through the fallacies fueling the Army's qualms about the Mustang. In June 1941, the Air Corps became subordinate to the Army Air Forces, abbreviated AAF. The initial contract for 310 combat Mustangs for the AAF was dated Oct. 20, 1942, but the fighters wouldn't become ubiquitous in European skies until late 1943.

A telegram dated July 5, 1943, from Materiel Command to North American conveys the intensity of the newly found interest in the Mustang:

"An urgent directive has been received from the Chief of Army Air Forces to provide the maximum combat range at the earliest possible date. It is requested that an immediate study be made to determine the method by which the maximum possible internal protected fuel can be carried in (model P-51B and subsequent)

A Mustang on a test flight in 1942.

airplanes and that the contractor submit a plan for the incorporation of such provisions."

On Aug. 17, 1943, a two-pronged attack employing nearly 400 heavy bombers was launched from England. Col. Curtis E. LeMay led one formation attacking the Messerschmitt aircraft factory at Regensburg while the other was directed against a ball bearing plant at Schweinfurt. Both German targets were beyond the range of the escort fighters then available.

881 AIRPLANES PER MONTH

Arnold, attending a conference in Canada, was handed an envelope. It was an after-action report on the raid. He winced as he read that 60 B-17s had been shot down and nearly 600 airmen killed or captured. Arnold knew the Eighth Air Force bomber fleet couldn't sustain that level of combat loss. Fighter protection was needed and the P-51 was best-suited to provide it. A North American internal memorandum dated one week later, Aug. 25, 1943, stated:

"The Army is requesting fuselage self-sealing fuel tanks in as many P-51 airplanes as possible. The urgency of the request is based principally upon the recent loss the [Allies] have experienced on long-range bombing ventures without fighter protection. … It is proposed that a change point be established as soon as possible in the P-51 airplanes."

The requested changes would not be fully implemented until the P-51D models rolled out of the Inglewood and Dallas plants; however, improvements appeared incrementally as all aspects of the design were studied, evaluated, and re-evaluated.

Among the refinements: the "birdcage" canopy was replaced by a clear bubble; armor was installed in the firewall to protect engine cooling components; and additional armor plate was located behind the pilot's seat. The heavy copper radiator was replaced by a lighter aluminum version. Sealed balanced ailerons were installed on the wing tips. A rubber-like self-sealing material was installed in the fuel tanks to stem the loss of fuel from bullet holes.

The only unused space remaining in the Mustang was in the fuselage behind the pilot. The battery, radio, and oxygen tanks residing there were relocated and the space freed up was filled by an 85-gallon fuel tank. The new fuel tank made the Mustang unstable until the fuel in it was consumed, but pilots adapted.

By far, the greatest improvement to the Mustang was in the engine. Ronald W. Harker, a tenacious British civilian test pilot working for Rolls Royce, was the first to propose installing a Rolls Royce Merlin V-12 engine into the P-51 airframe. Work started in England in August 1942 with a first flight on Oct. 13, 1942. NAA emulated the project, and the performance profile of the Mustang was shifted from low to high altitude. The Merlin was built under license in America by the Packard Motor Car Co. The original three-bladed propeller gave way to the distinctive four-bladed version from either Hamilton-Standard or Aeroproducts.

With changes made, P-51s were rolling off assembly lines at Dallas and Inglewood at the dizzying combined pace of 881 airplanes per month by January 1945. Ultimately, nearly 15,600 Mustangs of all variants were built by North American.

The P-51 is considered by many to be the best all-around fighter of World War II. As the war progressed, only the P-51 had the long range necessary to accompany heavy bomber formations from their home bases in England to targets deep in Germany and safely return.

Its dual role was to defend B-17s and B-24s from enemy fighters while destroying the Luftwaffe, either on the ground or in countless dogfights. With wing tanks drained and jettisoned and fuselage fuel consumed, a flight of 7.5 hours was common, with sufficient reserves available for some full-throttle combat with the Luftwaffe. Scores of Allied aces were "made" by the P-51.

Though the fighter aircraft arrived late in the Pacific Theater, the Mustangs went on to serve with distinction during the climactic days of World War II, when they were called on to escort Boeing B-29s flying bombing missions against targets on the main islands of Japan.

The last call to battle for the iconic North American single-seat fighter (renamed F-51 when USAF was formally established in 1947) was during the early days of the Korean War, starting in June 1950. Some 62,607 American-flown Mustang sorties resulted in the loss of only 474 F-51s.

A double-fuselage version of the aircraft, called the F-82 Twin Mustang, was initially requested by the AAF for very long-range escort of bombers to support the invasion of the Japanese home islands. These Twin Mustangs also served with distinction in the Korean War.

The powerful and graceful P-51 remains a darling of the annual Reno Air Races and the summertime air show circuit to this day, belying none of the teething problems it overcame. ✪

John Fredrickson served more than 20 years in USAF and the Reserve. In 2011, he retired as a senior manager at Boeing. This article is adapted from his book Warbird Factory: North American Aviation in World War II. *Fredrickson's most recent article for* Air Force Magazine *was "Eisenhower's B-25" in December 2014.*