



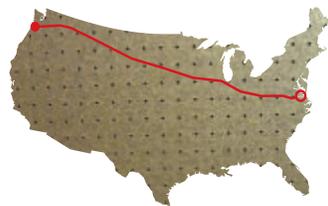
Scratchbuilt Record-Breaker

Arnold Ebneter's speedy design: 52 years in the making

Whether measured by time or distance, Arnold Ebneter, EAA 450548, has come a long way.

On July 25–26, 2010, he flew his single-seat original design—the E-1—from Everett, Washington, to Fredericksburg, Virginia, setting a world nonstop record of 2,327.85 statute miles for Class C-1a aircraft with a maximum takeoff weight of 500 kilograms.

BY CRAIG O'NEILL



That's the distance. In terms of time, that flight was the culmination of a 52-year design, build, and test process dating to 1958, when the E-1 was the subject of Arnold's senior engineering thesis at Texas A&M University.

Even by homebuilding standards, that's a long project. Yet in talking with Arnold, it seems that he never had much doubt of his project's eventual completion. "I said in the paper that I'd build and fly this airplane someday, 'time and circumstances permitting,'" he said with a twinkle in his eye.

EARLY EDUCATION

Arnold began notching up aviation experiences and accomplishments long before 1958. Now 82, he made his first flight as a passenger in 1936 in the little town of Mount Horeb, Wisconsin. "They had a couple planes land on the golf course there, and I got a 15- or 20-minute ride for a dollar," he recalled.

Arnold began flight training in 1943 in a J-3 Cub. "It had a Franklin engine and no brakes; they were

\$100 extra!" he said with a chuckle. In the 67 years since that first lesson, Arnold has never been out of currency.

When the local fixed base operator bought several surplus L-4s, Arnold helped rebuild the tired Pipers in exchange for continued lessons. "There was a lot of work in re-covering them. But it also counted as experience towards an A&P [airframe and powerplant mechanic certificate], so that proved valuable later.

"I figured out while I was in high school that if I could get a commercial and a flight instructor's rating and an A&P, why, then I'd have the world by the tail," Arnold said. "In later years I amended that: Maybe I ought to have an engineering degree, too."

Arnold earned his private ticket in 1946, taking his checkride in a PT-23. By the time he was a sophomore at the University of Minnesota, he had added commercial and instructor certificates and was instructing for the university flying club. There, he helped restore more L-4s, eventually logging enough hours to pass the A&P mechanic test.

THE DREAM IS BORN

In 1953, Arnold started pilot training as an aviation cadet at Goodfellow Air Force Base in Texas. He earned his military wings with Class 54-E the following March. Having graduated near the top of his class, Arnold had his choice of assignments.

“At that time the F-86 was what everybody wanted,” he said. After a year in the Sabre, Arnold moved up to the even hotter F-100 Super Sabre. From 1955 to 1958, his unit pioneered in-flight refueling tactics, mating the F-100 with the KB-50 tanker for flights as long as a 4,000-mile nonstop from South Carolina to Morocco.

By 1958, Arnold had accepted a regular commission, and the Air Force sent him to Texas A&M to finish his degree. It was there, while fulfilling the final requirement of his bachelor’s degree in aeronautical engineering, that Arnold first conceived the E-1.

“The aero department required that every senior write a research paper,” Arnold said. “I had been looking through Jane’s All the World’s Aircraft, and I ran across the Heinonen HK-1, an airplane designed by a guy in Finland. It was a little aerobatic airplane with a 65-horse Walter Micron four-cylinder inline engine.

“In ’56 or ’57, Heinonen had hung a big fuel tank underneath the thing and flown from Spain to Finland to set a distance record of 1,766 statute miles for this class of airplane. And I thought, well, that’s kind of interesting.”

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“So I took a cut at writing it, and the pros just went gaga,” Arnold said.

Arnold’s thesis laid out the design parameters of the aircraft that would eventually become the E-1. Recounting his process, Arnold said, “Obviously, you want an airplane that’s as

small as possible. And you don’t want to hang the fuel underneath like Heinonen did. You want to put it in the wings so the bending loads go way down. So you make the wing just big enough to carry the amount of fuel that’s going to be required, and that determines the wing area.

“The next question is the aspect ratio of the wing. Conventional wisdom says it ought to be as high as possible, but if you make the wing long enough, eventually the bending loads make the spar so big that you can’t put any fuel in the wing. So you play this back and forth and find out that an aspect ratio of just a little over 10-to-1 is optimal. Suddenly it becomes a very nice, practical airplane. That was probably the biggest surprise that came out of the study.”

Arnold’s analysis ultimately defined an airplane carrying 60 gallons of fuel in a 60-square-foot wing with a 23-foot, 8-inch span and a 15 percent-thick airfoil. Many more years of his aviation life would pass, however, before “time and circumstances” allowed the E-1 to become more than an academic exercise.

GETTING STARTED

After graduating from Texas A&M, Arnold went back to flying F-100s. He characterizes his assignments in the late 1950s and early 1960s as spending a lot of time overseas “sitting on alert with a big bomb strapped under you.”

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Arnold began designing his E-1 as part of his studies at Texas A&M in 1958. The finished product took him across the country and back in 2010.

In 1965, after a four-month tour in Vietnam as his squadron's maintenance officer, Arnold was assigned to the Air Force Institute of Technology at Wright-Patterson Air Force Base in Ohio to earn his master's degree. He then volunteered to return to the war. Over the next eight and a half months, he added 300 more F-100 missions to the 25 he flew during his first tour, amassing a total of 427 combat hours. "It all went pretty smoothly," Arnold said. "I only got two holes in the airplane and none in me."

Even while Arnold was being shot at over the rice paddies of Vietnam, the E-1 was never far from his thoughts. "I had all my stress analysis notes from college, and even in Vietnam, I played with them when I had a bit of time on my hands," he recalled.

After a final five years of stateside Air Force service, Arnold sought jobs with Cessna and Beech, but ended up signing on with Boeing. His work there didn't involve general aviation, but he found the Seattle area convivial to his avocational interests.

"I discovered surplus stores that had all kinds of good materials for building sport airplanes, so the design process really got going again," Arnold said. "I'd say, 'Okay, I need an extrusion with these properties,' and I'd run down to the surplus store to see what they had. They wouldn't have exactly what I had in mind, but they'd have something pretty close, something that could be modified to do what I wanted it to do. So I'd go home and redesign the part. It was an iterative process."

While working on the 767 by day and the E-1 by night, Arnold kept his A&P hand in practice by restoring a basket-case J-3. He kept his piloting skills sharp in the B35 Bonanza that he still flies today.

Finally, in 1995, Arnold began cutting aluminum for the E-1. Although a small airplane of conventional construction, it was no quick-build project. Except for one fuselage bulkhead that Arnold adapted from the remains of a BD-5 kit, every rib and bulkhead in the airplane was hand-formed over wooden blocks.

As the E-1 began to take shape, some ideas that had made sense on paper ran afoul of workshop realities. The landing gear, for instance, was retractable in the original design but turned out stiff-legged on the finished airplane.

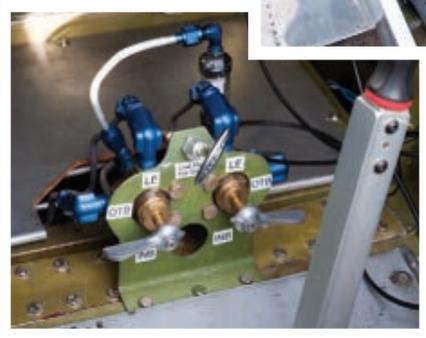
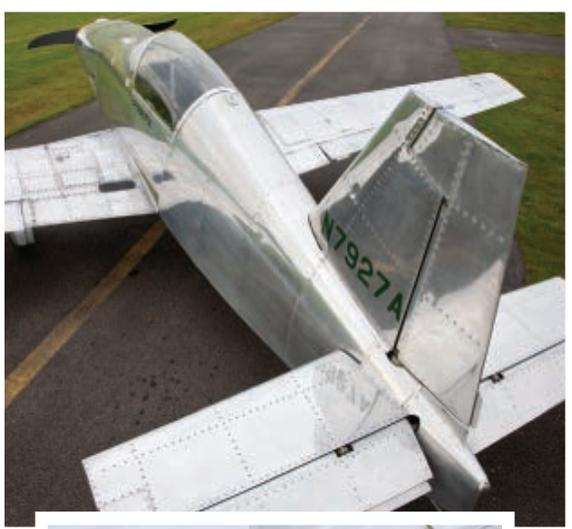
"I found that retractable gear was easy to draw but not so easy to build," Arnold said. Analysis convinced him that the efficiency gains of folding gear were a poor exchange for the increased weight and safety risk.

Another change that occurred during the build was in the powerplant. While in the service Arnold dragged a Continental C-85 from post to post, intending someday to hang it on the E-1. Then he discovered the Australian-built Jabiru 2200, which was not only 30 pounds lighter than the Continental but also narrow enough to be fully cowled, even on the slim fuselage of the E-1.

In 2002, the E-1 finally left Arnold's suburban garage for final assembly in his hangar at Harvey Field (S43) in Snohomish, Washington. First flight from Harvey's 2,700-foot runway came on July 7, 2005.

Arnold was immediately pleased with the E-1's flying characteristics. "Aileron forces are a little bit higher than I'd like, but it's very stable in pitch, and in yaw, it's on rails. It would be a very good gun platform!" he said.





The initial test flying revealed a couple challenges, however. The first was a pronounced tendency to float on landing. Recalling the first flights of the E-1, which had no flaps, Arnold said, “When you flared, it was as though the drag went to zero. After a few flights, I decided I had two choices: I could either put flaps on it or move it to another field.” Arnold has been based at Harvey Field since 1974, where he’s given more than 1,000 checkrides as the staff examiner, so he added split flaps to the E-1.

As with other features of the design, Arnold used computer tools to analyze the flaps. Previously, he had used the X-Plane simulation program to model the E-1’s unusual mid-span ailerons and had found that the program’s predictions matched the actual flight characteristics very closely. “When I modeled the flaps, X-Plane predicted a little pitch-up when you put the flaps on, and when I flew the airplane, yep, there it was,” Arnold said. “It’s very satisfying to see things like that.”

With the landing behavior tamed, Arnold tackled the next challenge in his flight-test program. Although he was learning all he needed to know about the E-1 at light weights, he knew that the aircraft would perform differently at gross weight. But when achieving gross weight requires a 20-hour fuel load, one doesn’t just top the tanks and blast off to run a few test cards in the local practice area, especially when the maximum landing weight is hundreds of pounds below gross.

Arnold’s solution was elegant in its simplicity: conduct his gross-weight flight testing in a constant, 45-degree banked turn. “At an actual weight of 785 pounds and 1.4 g’s, the load on the wings was 1,100 pounds,” Arnold said. “I’m not sure what the guys down at ATC [air traffic control] must have thought to see this airplane turning circles for 20 minutes at a time while I burned a gallon of fuel, but the GPS told me exactly how far I flew while doing that. It was far better data than I could get any other way.”

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CLAIMING A RECORD

Finally, all that remained for the record attempt was to wait for the right weather. But when that means uninterrupted visual meteorological conditions across the width of the continent, the wait can be lengthy. Every evening for two summers, Arnold reviewed the next day’s forecasts on DUATS. Once in 2009, he thought he had the conditions he needed, but at the last minute, local conditions caved in, preventing an escape over the Cascade Mountains to the fair weather to the east.

Then on July 24, 2010, Arnold saw another window. The next morning everything looked good so he made the “go” decision. His flight planning predicted a flight time of 18 hours and a fuel reserve on landing in Virginia of 3 to 4 gallons.

Arnold positioned the E-1 from Harvey Field to nearby Paine Field, where the 9,000-foot runway would provide more margin for the airplane's first-ever gross-weight takeoff. He also called in the local National Aeronautic Association representative to officiate over the formalities of the record attempt: weighing the fully fueled airplane and sealing the barograph that would prove there were no surreptitious landings en route.

With the E-1 perched on a set of recently certified scales, 50 gallons of fuel were added. Then Arnold got in with the water and energy bars, and more fuel was added until the scales hit 1,102 pounds.

Despite visible differences in landing gear geometry due to the weight, Arnold experienced no adverse changes in the E-1's taxi or takeoff performance, and with the Jabiru humming smoothly, he banked to a heading of 90 degrees and climbed at an average of 500 feet per minute to his cruising altitude of 9,500 feet.

"It got right up there," Arnold said with a grin.

The E-1 is equipped with the Dynon FlightDEK D-180 electronic flight instrument system with altitude-hold autopilot, an investment of a couple extra pounds that Arnold found well worthwhile. "I had 20- to 25-knot tail winds over the mountains, so I got into some pretty good wave effect. To hold 95 knots [the flight-planned maximum duration airspeed], I was having to play autothrottle. But the Dynon did a really good job of holding altitude and cut the workload quite a bit," he said.

Arnold also had the benefit of onboard XM weather, but ironically, the only storms encountered—in eastern Montana—barely showed up on the Garmin 496 because NEXRAD coverage is so spotty in that part of the country.

Arnold remained at 9,500 feet until forced to duck under an overcast sky in the Dakotas. This descent initially put a bit of wind on the E-1's nose and caused Arnold some anxiety about his prospects for bagging the record.

Heightening these worries was the failure, shortly after takeoff, of the E-1's fuel flow meter—the only mechanical glitch Arnold encountered. With the fuel totalizer showing no consumption, it wasn't until Arnold was over Ohio and the last of the wing fuel had been pumped into the 9-gallon fuselage tank that he was able to determine his fuel state with precision.

"At that point, with the groundspeed I was making, it looked like it was going to be pretty touch and go," he said. "The forecast called for better winds ahead, but it looked like I was going to get there with about half a gallon remaining. It wasn't five minutes later that the groundspeed started picking up. I climbed back up to 7,500 feet and, sure enough, got a pretty nice tail wind."

At 11:30 a.m. local time—exactly 18 hours, 30 minutes after leaving the ground in Everett—the E-1 alighted at Shannon Airport in Fredericksburg. Two-and-a-half gallons of fuel remained—enough for another 75 miles of flight—but they were not needed: According to Fédération Aéronautique Internationale rules, distance record flights must exceed the established mark by at least 1 percent. Arnold's flight bested the old record by more than 8 percent.



Throughout Arnold's Air Force career he chipped away at the E-1's design, waiting for the timing to be right to begin building.

WHAT'S NEXT?

After a 52-year project, a seven-year build, and an 18.5-hour flight culminating in a world record, Arnold is now faced with figuring out exactly what to do with the E-1.

"It's proven its point," he said. "But I think I'll continue to do some research with the airplane." He mentions possibly replacing the E-1's partial wheel fairings with full wheelpants. He has some ideas about wingtip designs. He ponders experimenting with lean-of-peak operation.

"I'm not eager to run out there and do another 18- or 20-hour flight with it," Arnold said. "But there are some things I want to play with."

That is as neat a summation of Arnold Ebnetter as one is apt to find. Though manifestly an accomplished pilot and builder, he is—first and foremost—an engineer. While having a world-record plaque is an obvious source of pride, more important is the validation of his engineering. For Arnold, the thrill of the record chase was in the translation of requirements into a design capable of meeting them.

"Every aeronautical engineer dreams of designing his own airplane," Arnold noted. "This was a chance to design the airplane, build it and also do the first flight on it. Homebuilding is the only venue for that, and that's the heart and soul of EAA."

Somewhere, Arnold's old A&M professors are very proud.

Craig O'Neill, EAA 490534, is an instrument-rated private pilot with about 1,200 hours of flight time. He is Director of Marketing for a Part 135 commuter seaplane operator in Seattle, Washington.