LONG-EZ
WITH A PURPOSE

ARTICLE AND PHOTOS BY JEFF RICHMOND


Tim prepares to depart First Flight Airport on a research mission. The Wright Brothers Monument is in the background.

Tim Crawford is not the first pilot to start building an airplane before he took his first flying lesson, but how many pilots have flown more than 3,000 hours on their third aircraft in fewer than 10 years?

Tim — a Ph.D Engineer for the Tennessee Valley Authority at the time — first learned that it was possible to build and fly his own airplane when he attended an EAA Fly-In at Tullahoma, TN in 1980. At that event, he met and talked with Burt Rutan, and the rest, as they say, is history. It took Tim three years to build his first Long-EZ.

Tim has been involved in building five aircraft: two Long-EZs, two twin-engine Defiants, and a Velocity. He sold the first Long-EZ about a year after it was completed, and went into a partnership to build the first Defiant. In Tim's words, "The Defiant is a massive homebuilt project. The first was built in one year and flown to Oshkosh." The second Defiant was actually his fourth aircraft, but he sold it when only 80% complete because he "fell in love" with the Velocity Elite RG, "with its gull wing doors" — which he still has.

By the time he had started his third aircraft, Long-EZ N3R, Tim had gained enough experience to make some changes. "I started building N3R on my birthday in September 1985. It was finished on July 4, 1986." The changes in the design were driven by the instrument panel. "At the time I was excited about IFR and I knew I wanted a serious IFR aircraft. So, I built the instrument panel first. It was three inches wider to fit the instruments I wanted. The three inches set the scale for the rest of the fuselage.

"From there, I modified the design from the ground up," Tim explained. "I also wanted more shoulder room. I made the fuselage 4 inches wider, 2 inches deeper, and 14 inches longer. The 14 inches come from a 12 inch longer nose and 2 more inches of leg room in the back. The wings are 4 inches longer and the winglets are 3 inches taller." Tim adds, "Neil Hunter inspired me to build my second Long-EZ after he let me fly his 'Big-EZ' which was 7 inches wider." Tim has decided that N3R is a "keeper."

N3R incorporates other enhancements over Rutan's original design. The airframe is stronger to withstand +9, -6 Gs and is certified for aerobatics. Tim says, "To get N3R certified for aerobatics, the FAA required I demonstrate aerobatics during a test flight. However, I never worked at it so I have never gotten really good. I can still do a clean loop and a roll — sometimes," he adds with a big grin.

The fatigue-resistant, high-strength composite structure allows safe operation in the extreme turbulence often encountered during low-level operations. Twenty percent larger than a standard Long-EZ, N3R is powered by a 160 hp Lycoming O-320. It has an empty weight of 950 pounds and a maximum gross takeoff weight of 1,800 pounds.,

Tim has had three propellers on N3R. "The first was a two-blade prop from the Great American Propeller Company. It worked great," Tim said, "but I thought I could make a better one, so I designed and made one with thinner blade sections wrapped in carbon fiber. It was a few knots faster, but the stiff blades increased the takeoff roll."

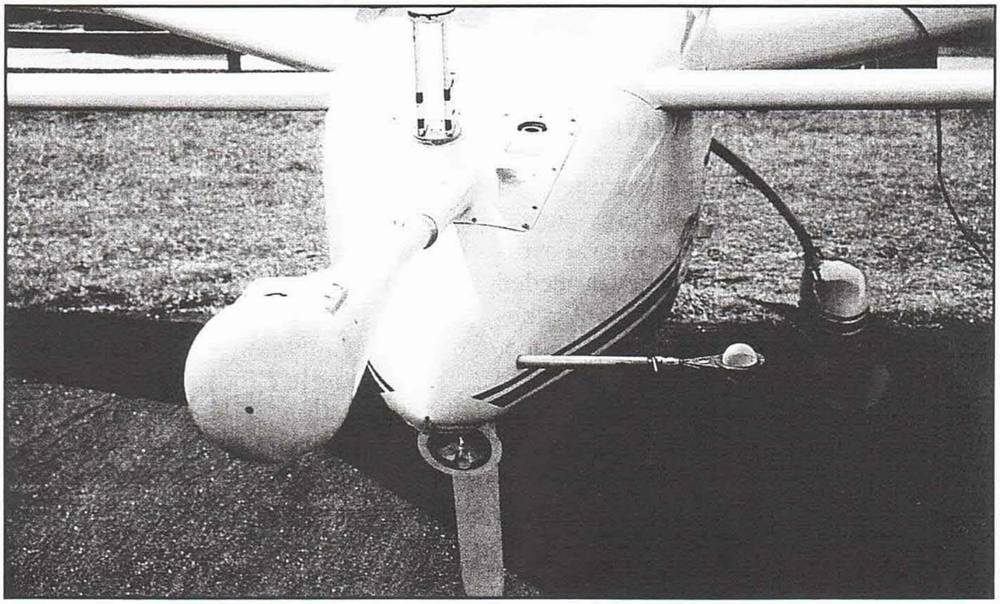
N3R now has a three-blade propeller. Tim explained why. "About five years ago both props were damaged by rocks on runways in Barrow, Alaska — talk about a freeze-thaw problem. Anyway, I repaired both props, but I knew I had to do something to stop the problem. The two-blade propellers were too long. I knew a three-blade propeller could absorb the horsepower with less diameter, but, to my surprise, N3R is even faster and quieter with the new prop." Tim reports that the new prop gives N3R a full-throttle speed of 175 kts. indicated at 8,500 feet.

N3R also carries a BRS ballistic recovery parachute system. This can be deployed in less than a second. The canister containing the chute is bolted to the center-section spar. A very thin fiberglass "blow out" patch is installed above the canister for chute deployment. The chute is tied to the airframe with a three-point Kevlar harness, configured to lower the aircraft in a level attitude. A 4-point 40 G restraint harness and safety-foam crash seats are also part of the safety equipment.

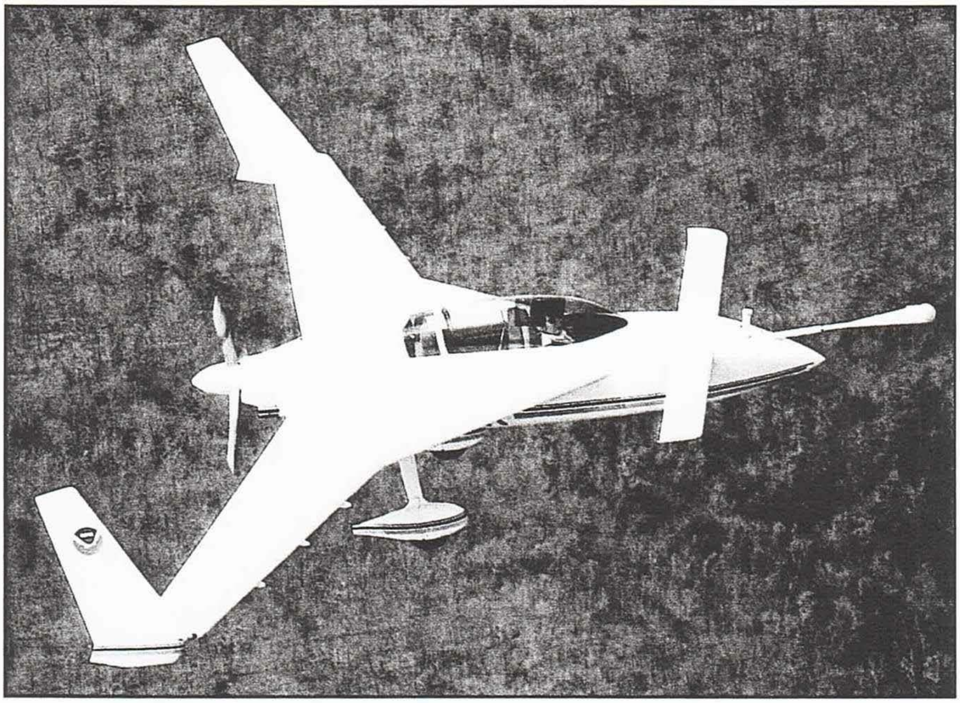
When not instrumented for research, N3R carries two people with limited baggage. The expanded 73 gallon fuel capacity provides up to 10 hours endurance at 200 mph. An optional long-range fuel tank can be installed, increasing fuel capacity to a total of 100 gallons and extending range to 3,500 miles, sufficient to ferry the aircraft anywhere in the world.

N3R is fully IFR-equipped with a two-axis autopilot, dual nav-coms, an IFR GPS receiver, a Stormscope and an oxygen system.

In 1990, Tim went to work for the National Oceanic and Atmospheric Administration's Air Research Laboratory. His assignment was to work with the Atmospheric Turbulence and Diffusion Division (ATDD) in Oak Ridge, TN. ATDD had been established in 1947 to study the wind and weather around Oak Ridge to predict possible dispersion patterns of radiation and

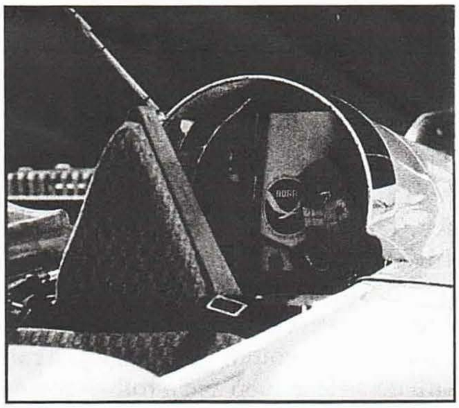


The BAT probe extends ahead of the aircraft in undisturbed air. Holes on the spherical surface detect winds from all directions and angles. The vertical instrument at the base of the probe is an infrared gas analyzer that measures water and carbon dioxide. The square antenna on top of the probe is one of the Trimble TANS Vector System antennas.



Tim Crawford pilots his research-instrumented Long-EZ. The BAT probe senses crosswinds as well as vertical air currents. The aerodynamic shape and pusher-prop configuration of the Long-EZ allow the BAT probe to penetrate undisturbed air. The infrared water vapor and carbon dioxide sensor is located at the base of the probe. Tim is the director of the Idaho Falls NOAA Field Research Division, which explains the NOAA insignia on the winglets.

N3R at the site of the flight of another famous canard aircraft — the Wright Flyer.



The BRS parachute system is nestled behind the rear cockpit. There is a lightweight blow-out panel directly above the canister for chute deployment.

chemical gases if they were accidentally released from one of the nuclear research facilities in the area. Fortunately, their studies were never needed for their intended purpose, but it became apparent that their experience, methods and facilities could be used to study industrial pollutants, global warming, greenhouse effects and related atmospheric research.

A key to these studies is the pattern of air movement near the surface. It was determined that understanding vertical air currents could help predict the transfer of carbon dioxide and other substances between the ground, vegetation and the air. This information could have a significant impact on our understanding of the chemistry and concentration of greenhouse gases. Originally, research was conducted using instrumented towers to monitor air movements. Although effective, each tower could collect data from only one location.

Tim and his colleagues realized that it was necessary to take measurements over a large area in a short period of time in order to fully understand the atmospheric effects they were studying. With this in mind, Tim set out to equip his Long-EZ as a research aircraft.

Much of N3R's research involves detecting and measuring wind. Consider this challenge: not only detect, but measure the direction and speed of a wind about as strong as a child's breath as you fly by at 100 mph. That challenge was solved using the most prominent feature on N3R, the BAT ("Best Aircraft Turbulence") probe, which Tim invented. A radial pattern of nine equally spaced holes on the spherical end of the BAT can detect wind speeds as light as two centimeters per second from any direction — vertically to horizontally.

Wind measurements from an airplane are simple in concept. To compute the average horizontal wind the only information needed is ground track, ground speed, true heading and true airspeed. From these four variables, a wind triangle can be solved for the wind direction and speed. Tim's BAT and the support software solve the "wind triangle" in three dimensions.

The Long-EZ is an ideal platform for this research. The clean aerodynamic shape of the aircraft and the pusher prop allow the BAT to sample undisturbed air in front of the aircraft. The onboard differential GPS and a Trimble TANS Vector System, with four antennas located on the upper surface of the aircraft can determine aircraft position within ±3 m, velocity within ±2 cm/s, and attitude angles (pitch, roll and heading) within ±0.05 of a degree. This data is sensed at a rate of 50 times per second (50 Hz). This allows the onboard computing system to accurately compensate for aircraft speed and attitude and solve the wind triangle for very light wind currents.

To fully understand what is happening in the environment, sensors also measure air temperature, water vapor, carbon dioxide, ozone levels, dew point, and surface temperature. When required, the aircraft can be equipped with a laser altimeter and video cameras. Tim also has a pod-mounted Ka-band radar altimeter that can be mounted under the center of the fuselage.

Using the Long-EZ in field research is straightforward. When fully instrumented, the rear cockpit is occupied by a computer and instruments. Because only one pilot flies the airplane to collect data, the data acquisition system is highly automated. The onboard research computer is a fast PC-type computer capable of collecting and processing up to 32 sensor signals, also at a rate of 50 Hz. This means data is collected and recorded approximately every meter at a speed of 50 m/s (approximately 100 kts.). The computer completes all of the preliminary computations to provide wind data. After each flight the computer data is saved on disks for more detailed analysis.

Tim has conducted research flights in his Long-EZ from Florida to the North Slope of Alaska, and Hawaii. One of their more recent projects involves studying the interaction between winds and waves in coastal waters. Conducted in collaboration with the Office of Naval Research, Oregon State University, and the National Center for Atmospheric Research, the research is intended to better understand the relationship between waves, wind, coastal geography, and water currents. The Navy expects to use this data to improve targeting systems for sea-skimming missiles.

For this research, N3R was equipped with both a sensitive radar altimeter and a laser altimeter. The laser altimeter can measure the difference in height between the trough and crest of a wave with an accuracy of ±1 cm. At the same time the local wind speed and direction, air temperature, and humidity are recorded. During one three week period in March 1999, flying out of First Flight at Kitty Hawk, NC, Tim and fellow scientist/pilot Ed Dumas flew more than 75 hours, collecting data that may take two months to analyze and understand.

A typical mission for the Long-EZ lasts from three to six hours. Each flight begins with detailed preflight planning of the track to be flown, altitudes, weather, communications schedules, and safety and contingency plans. If the flight time to be flown in one day exceeds six hours, Tim and Ed split the flying duties. While conducting research flights over the North Slope of Alaska, Tim and Ed logged 21 hours during four flights in one day. When the aircraft lands, members of the research team collect the computer data and take it back to the local operations center and download it for preliminary analysis. Although it may take several months to fully analyze the data, the research team can get enough information to adjust the flight plan for the next day.

During field experiments, a field office is set up in a local hotel room with telephone service, electric power, and access to the roof or other open space for the GPS and VHF antennas. The field office is equipped with data processing computers, Internet access, a GPS ground station, and radio communications. From the field office, the research team and the scientist/pilot evaluate weather, plan missions, file flight plans and, if required, reserve airspace.

Flight safety is the first issue addressed in program planning, deployment, and daily operations. Both Tim and Ed are experienced commercial instrument-rated pilots. The scientific efficiency of their research is enhanced because the pilots are also scientists and members of the research team.

N3R offers significant advantages over other research aircraft. Lockheed P-3s and C-130s are great for flying into hurricanes, but are not operationally or economically feasible for extended low-level research. The Long-EZ's low operational cost allows researchers to gather significantly greater amounts of data within their budgets, and allows smaller research programs to have access to a research aircraft. N3R also operates in remote regions with minimal on-site support. Using a local airport near a research site enhances research efficiency by reducing ferry time to the research area.

Another advantage of the Long-EZ is that it is relatively quiet, and its unusual shape typically attracts favorable comments rather than citizen complaints. Tim is quick to point out that all flights are conducted in compliance with Part 91 of the Federal Aviation Regulations, including the minimum altitude restrictions. Operations over water have few restrictions except that appropriate survival and navigation gear are carried.

Tim takes his science, research, and flying seriously. What would be a dream job for many pilots is a passion for Tim. First, Tim says he wants their research to be useful, not just for scientific purposes, but to help resolve problems that will improve the environment — and people's lives. When talking about his aircraft, Tim is frequently heard to say, "It's not about the flying. It's about the science." Understanding and properly managing our environment fits into his sense science and purpose. And he gets to fly a lot doing it.

Note: For the record, Tim is also an EAA Technical Advisor. For more information about Long-EZ N3R, go to www.atdd.noaa.gov.long_ez. For details on Tim's BAT, check out www.atdd.noaa.gov/bat/bat.htm. This page also has links to Tim's research and related sites. ◆