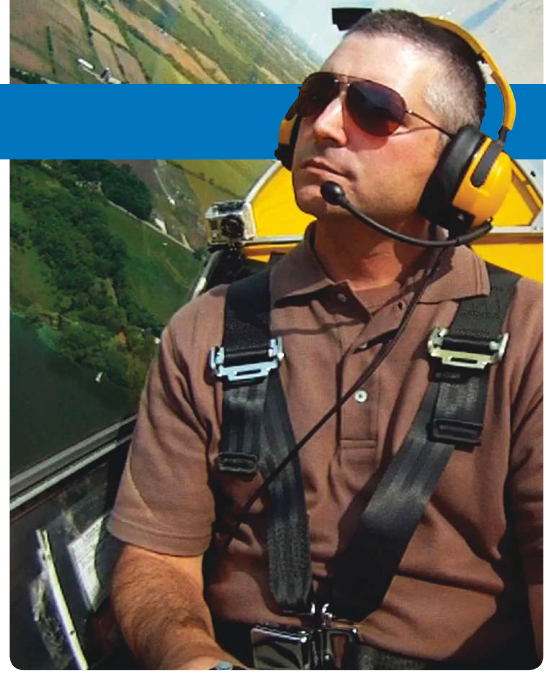
EAA EXPERIMENTER
The Spirit of Homebuilt Aviation | www.eaa.org
Vol.2 No.3 | March 2013

The Eclectic Ellipse

A Dean Wilson masterpiece

» **Grand Champion Cozy IIIP**
Long build with lots of innovations

» **Picking an Engine for your Project**
What you should consider



Forums

Great places for information sharing

By Chad Jensen

I was thinking about the word "forums" recently and how it related to our homebuilt airplanes. I can't think of another word that has changed in overall reach and increased in breadth more over the 60 years of EAA history. Nowadays, the basic word has a number of meanings according to Dictionary.com. Two of them are relevant to our discussion. Both provide the opportunity for information exchange, but they give that opportunity in drastically different ways. An "old" definition, which is still very relevant today, is "a meeting or medium" where ideas and views on a particular issue can be exchanged.

This definition represents what many longtime EAAers know as the group meetings that have been taking place at the convention since the early days where someone, typically a subject matter expert, will stand in front of a crowd and give a presentation on a topic or issue. We still do these forums to this day at EAA AirVenture Oshkosh. In fact, we do so many that you could pack your entire week of convention with forums!

The other side of forums as we know them today is in the world of electrons and digital information on the Internet. The definition of forums in this case is simply an Internet message board. These "boards," as many people call them today, can be an absolute wealth of information. I do have to add a word of caution to that statement, however. There are members of forums who present bad information, knowingly or not, so just be sure that what you read on Internet forums is taken with a smidgeon of salt, but rest assured that much of the information you will find is good and useful.

The boards available to builders today are so popular that people become friends on the Internet well before they ever meet face to face. Think about this. I am just old enough to remember when the word "Internet" was not a part of anyone's vocabulary. Today, it's so prevalent in our world that we are making friends with people of common interest without ever seeing them! Some of my very best friends have come from the period of my life when I built the RV-7 and used forums regularly. Although I sold the airplane, I still have the friends.

EAA launched its new message board, http://EAAforums.org/forum.php, in July 2012, and it has proved to be a popular place for people of all build levels and diverse interests to come together to get answers to their questions and for others to pass along information to help the next person get started. There are numerous forums for almost every type of homebuilt you can imagine, and if you haven't found the right online meeting place yet, do a search for your type, or check out EAA Forums for wonderful information along with some great camaraderie and new friends! EAA

On the cover: A great view of the elliptical wing of Scott Christiansen's Ellipse. (Photography by Phil High)

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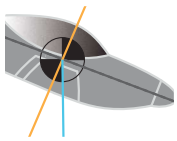

CC's…Not Liters

At over 1100 liters, I reckon the Italian Stallion LSA motor in your recent article [February 2013, page 26] would indeed exceed the manufacturer's highest hopes. Fitting those 1100 liters (many of which are apparently invisible, if the photos are accurate) in my LSA would take a lot longer than 50 hours, if applicable at all.

Nor would the PSRU, the most important part of all on the engine, which wasn't addressed in the slightest in the article, be able to handle such raw and awesome and excessive combustion capacity! ...

Jackson Ordean
EAA 1049509

Our bad…Both the writer and editors missed that liters should have been cc's. We apologize for this error. We have great respect for the Corvair and Viking and will discuss those engines in future issues, but don't forget that Experimenter *is an international publication, and our European friends enjoy reading about products from their area. Some of those products may be offered in the United States, too. – Editor*

Safety Wire Article About Shoulder Restraints

I am somewhat surprised that there might still be any doubt about this. When I joined EAA over 50 years ago, Paul [Poberezny] required that every new member sign a pledge to install shoulder restraints, then known as a shoulder harness.

Except for the manner in which this is done, what's to discuss?

John R. Boyce
EAA 9082

John brings up a good point. The shoulder-harness pledge was common in the early days of EAA, and EAA's safety committee is discussing renewing that pledge. – Editor

It's a Small World

I was especially touched by the article "The Last Zero Mechanic," about Don Osmundson's half-scale replica of the Zero. The airplane is an incredible accomplishment, but even more so is Mr. Osmundson's war record and subsequent accomplishments.

I was fascinated to read about Mr. Osmundson's service on the Lexington in the Battle of the Coral Sea because I have been preparing a talk about one of his shipmates, Lieutenant (junior grade) William E. Hall. Mr. Osmundson may be interested to know that Lieutenant Hall will be inducted into the Utah Aviation Hall of Fame at Hill Air Force Base in Ogden, Utah, this Memorial Day. Lieutenant Hall earned the Medal of Honor for flying his SBD Dauntless dive bomber like a fighter and shooting down three enemy airplanes while protecting the Lexington. ...

All of our veterans deserve our respect and deepest appreciation. Mr. Osmundson, please accept a great big thank-you for your good work. Reading about what you have accomplished is an inspiration.

Van Twelves
EAA 770369

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Grunloh, Severen Join EAA Ultralight & Light-Sport Aircraft Council

EAA has welcomed two new members to the EAA Ultralight & Light-Sport Aircraft Council—Dan Grunloh, EAA 173888, of Loda, Illinois, and Scott Severen, EAA 181476, of Oak Point, Texas.

Dan Grunloh

Scott Severen

Grunloh, a retired scientist from the University of Illinois, attended his first EAA Oshkosh convention in 1981 and made his first solo flight in a hang glider in 1982. He has served as a weeklong volunteer in the Ultralight/Light Plane area at AirVenture for close to 30 years. In 1986 he completed a plans-built wood-and-fabric Sky Pup ultralight and began publishing the *Sky Pup News* builder newsletter.

After transitioning to weight-shift trikes in 1998, Grunloh won the 2002 and 2004 U.S. National Microlight Championships. He also flew in the 2003 (England) and 2005 (France) FAI World Microlight Championships and became one of only three U.S. pilots to earn a Gold Colibri for cross-country navigation.

Grunloh has logged 1,500 hours in ultralights and light-sport aircraft (LSA) and currently writes a monthly column for EAA's *Experimenter* online magazine.

Severen began flying hang gliders in 1973. He founded the Lone Star Airpark in Texas and has served as president of several organizations including the Airpark Owners and Operators Association, Light Aircraft Manufacturers Association, TEAM Aircraft, and the United States Ultralight Association (USUA). Severen was also a USUA director.

He was a charter member of the FAA Aviation Rulemaking Advisory Committee that created the sport pilot/light-sport aircraft regulations. Severen also is a member of ASTM International Committee F37 on Light-Sport Aircraft (F37.20) and has more than 2,000 hours in powered and nonpowered GA and LSA vehicles. Severen was a key player in the evolution and certification of the Thorpedo special light-sport aircraft (S-LSA) and served as an LSA flight conformance and test pilot.

Severen is a past USUA advanced flight instructor examiner and seminar presenter. He works at US Aviation as director of business development and lives with his family near Dallas, Texas.

Strong Rally Congress Response to Help Build GA Caucuses

More than 500 EAA members have accessed *Rally Congress* since it was launched in early February, prompting about 135 of those members to send more than 350 letters to their elected representatives in Washington, D.C., and urge them to join the General Aviation Caucuses. Thanks to those who have already acted, and we urge all members to take action and help grow the GA Caucuses.

The Senate and House caucuses have been instrumental in helping defeat user fee proposals and preserve aeronautical GPS signals, as well as in passing important legislation such as the Pilot's Bill of Rights and residential through-the-fence agreement language.

Through a series of retirements and changes in party, there are approximately 40 members of the two caucuses who have not returned to Washington this year. That means new representatives need to be encouraged to join the caucuses, which helps spread the word on issues of importance to sport and recreational aviation, as well as general aviation as a whole.

To take immediate action, visit www.EAA.org/rallycongress and click on the "Take Action" button. EAA has provided a letter that can be sent as-is with a single click, but members can also edit the letter as they wish, or draft and submit an original piece. Phone calls are also an effective, personal way to reach a representative.

Peter Burgher's Record-Setting Quicksilver MX-1 Now Displayed in EAA AirVenture Museum

The EAA AirVenture Museum's mission is to display sport aviation's innovation through exciting exhibits that showcase the significant moments in aviation history, and the stories and backgrounds of the innovators behind these achievements.

Another step in that direction took place recently when an Eipper/Burgher Quicksilver MX-1 was hung from the rafters, honoring the exciting world of ultralight aircraft, a record-setting aircraft, and its pilot.

The Quicksilver on display was owned by Peter Burgher, who made the record flight from his home in Utica, Michigan, to St. Petersburg, Florida, in the summer of 1982—a north-south trip never before attempted in an ultralight.

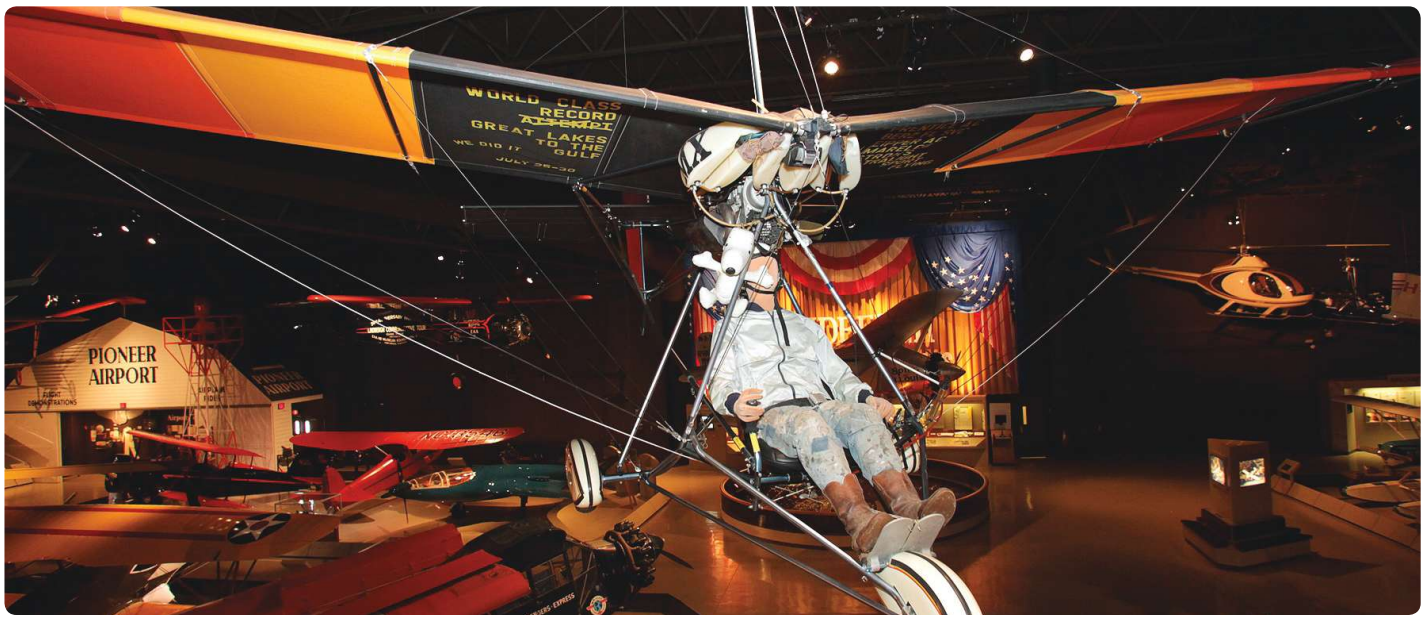
Burgher departed Utica's Berz-Macomb Airport on July 24, 1982. The ground crew consisted of Gordon Sorenson and Ira Breneman. Sorenson was the official National Aeronautic Association (NAA) observer who drove the communications car and kept an educated eye on the safety of the operation. Breneman drove the second car, which hauled a glider trailer containing a complete spare airplane, plus extra parts and fuel for the Quicksilver.

Burgher modified the MX-1 to prepare it for the long flight. He clipped the wings about 5 feet for increased airspeed, better gas mileage, and better handling in turbulence. Using special small jets in the carburetor, Burgher was able to reduce the gas consumption to an average of 2.6 gph in the Cuyuna-powered Quicksilver.

With help from his ground crew, Burgher completed his record-breaking trip that spanned more than 1,000 statute miles. The trip earned 56 world and U.S. national records, a record in and of itself. He made 26 scheduled landings and just two unscheduled landings over the course of his trip. The flight was estimated to take seven days, but thanks to the tenacity of pilot and crew, they did it in only five and a half days. According to Burgher, the main success factors were the selection of the aircraft, the full year of planning, the excellent ground crew, and just plain luck.

A year after Burgher's adventurous flight, in October 1983 he donated the Quicksilver MX-1 to EAA. He is the very same Peter Burgher who launched the chapter challenge to promote chapter activities and advance our EAA community of aviators.

Ultralights make up one of EAA's most significant segments of aircraft, providing an exciting and exhilarating way for people to enjoy wonders of flight. The nonstop action at the ultralight field during EAA AirVenture Oshkosh is a testament to the passion of the devotees of this community, and Peter Burgher's intrepid flight displays both the spirit of aeronautical endeavor and of EAA. EAA



Peter Burgher's record-setting Eipper/Burgher Quicksilver MX-1 hangs proudly from the ceiling at EAA AirVenture Museum.

Photography by Jason Toney

8,000th Van's RV Flies

On Monday, February 4, 2013, Stephen Watson of Santa Clarita, California, flew the 8,000th Van's Aircraft kit airplane that was completed. Watson's airplane is an RV-7A, powered by a Lycoming IO-360 turning a Hartzell constant-speed propeller.

For many years, Van's has posted on its website a running total of RV series kits completed and flying. Reporting first flights for the "Hobbs meter" of Van's kits is completely voluntary, so there are likely even more of the RV series airplanes that have flown.

Watson, who works for Jet Propulsion Laboratory in California, spent five years of part-time effort to complete his RV. He equipped his RV-7A with a Dynon SkyView flat-glass flight instrument system and a Garmin stack of avionics.

Just Aircraft's Highlander Available as SuperSTOL

Just Aircraft recently completed flight testing on its new Highlander SuperSTOL model, which can be built from a kit in the experimental amateur-built or light-sport aircraft categories.

The SuperSTOL's upgraded design features a new slatted wing and a virtually indestructible landing gear that can accommodate 21-inch tundra tires. With the improved landing gear features and long strut air shocks, it can handle aggressive off-airport landings. The SuperSTOL also has an empty weight of 720 pounds, giving it a useful load capability of 600 pounds.

"The new slatted wing has significantly enhanced the performance numbers and slow flight control," said Troy Woodland, design engineer. "This provides access to considerably more off-airport landing sites, making the SuperSTOL one of the most versatile backcountry machines out there."

The wing slats, when combined with the large Fowler flaps, allow the aircraft to be flown at extremely high angles of attack, permitting it to "drop" into small or inclined clearings.

With the new wing configuration, the Highlander will cruise at 110 mph, land at 32 mph, and take off or land with as little as 150 feet of runway.

Just Aircraft Company has shipped more than 300 Highlander kits in the United States and abroad. All existing Highlanders can be retrofitted with the new folding SuperSTOL wing. They can be built in tailwheel or tri-gear configuration and can be fitted with regular wheels, tundra tires, skis, or floats.

For more information, visit www.JustAircraft.com or call 864-718-0320.

Glasair Aviation Names Christopher Strachan as Director of Marketing and Sales

Glasair Aviation has announced the appointment of Christopher Strachan as director of marketing and sales. He will be responsible for redefining the Glasair and Sportsman brands for all promotion activity and sales strategies. In concert with the new ownership, Strachan will help drive the company's growth in the sport aviation market.

Strachan brings more than 20 years of experience in the aviation industry to Glasair, including knowledge of operations, marketing, product development, CRM, and sales. "Chris brings passion, energy, experience, and a unique perspective to our existing business and future plans," said Nigel Mott, president of Glasair Aviation. "He is a talented and skillful individual who understands the industry, our customers, and the Glasair brand. Glasair's new ownership reached out to Chris as part of a new plan for expansion and growth."

Strachan said, "As an aviator and aircraft kit builder, I am excited to work with this team, to see the technology and the vision. I've been around aviation all my life, and the thought of being at the forefront of aircraft design, new technology, and manufacturing embodies an experience I couldn't pass up."

He will be spending his time at the corporate office in Arlington and will represent the company at major trade shows. For more information, visit www.GlasairAviation.com.

CAFE's EAS VII to Be Held in April

The seventh annual CAFE Electric Aircraft Symposium (EAS VII) will be held April 26 to 27 at the Flamingo Resort in Santa Rosa, California. Sponsored by the CAFE Foundation, the symposium's theme is "Transforming Transportation With Electric Aircraft."

Pioneering scientists, including the top technology leaders from NASA, IBM, NREL, Stanford, MIT, and other leading universities, will explore the core technologies for emission-free flying machines.

Among the featured topics slated for discussion are battery breakthroughs, ultracapacitors, ultraquiet propellers, motors, high lift, ESTOL charging and energy management, speed records, UAVs, electric light-sport aircraft, nanotech structures, design software, solar capture, safety devices, and autonomous Sky Taxis.

Scheduled to appear are the two winning teams from the 2011 Green Flight Challenge, as well as the Solar Impulse team, which will present details about its electric aircraft. NASA's chief scientist will also present the latest in cutting-edge energetics.

Registration includes the opportunity to network with expert faculty at a choice of three theme dinners focused on motors, energy, and aeronautics. CAFE will also update plans for future Green Flight Challenges, plus provide a sneak peek at ultraquiet propulsion. Register online today.

California Power Systems Releases 2013 Parts Catalog

The new 2013 California Power Systems (CPS) parts catalog is now available. The catalog includes Rotax engines, Rotax parts, other engine parts, airframe parts, covering supplies, instruments, avionics, tools, pilot supplies as well as books and videos on ultralight and light-sport products. The catalog is available in a print format along with a downloadable PDF format.

CPS has been the Western U.S. Regional Rotax Service Center since 1981. In addition to engine and parts sales from the facility at Corona, California, CPS also maintains a maintenance shop and a Rotax engine training facility at the nearby Chino Airport (CNO).

For more information or to request your free copy of the new CPS parts catalog, call 1-800-AIRWOLF or visit www.800-Airwolf.com.

RV Airspace Celebrates One Year

RV Airspace, operated by RVer Glenn Brasch, EAA 151265, celebrates its one-year anniversary in March 2013. Discussions are growing daily on this newcomer RV forum. If you haven't checked it out yet, you'll find some familiar usernames there, and a little different feel than the other great RV forums offer. Visit www.RVAirspace.com.

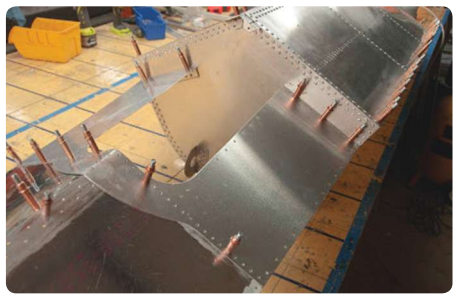
Belite Offers Showplane and Amphibious Floats

Belite's WOW showplane is for sale at a special price. It is loaded with features and special "one-off" touches, which make it a different, highly aerodynamic machine—achieving a 58-mph cruise on a 28-hp engine—and a joy to fly. It has a special paint scheme that has turned heads wherever it's been shown.

Originally priced at just under $50,000, Belite has reconfigured it to save money and added in a special discount as well as a reliable, new four-stroke engine. Only one model is available, but you can choose one of four configurations:

1) $26,500 with new 28-hp Hirth engine
2) $22,500 with new 28-hp Hirth engine and cost reductions
3) $32,500 with 1/2 VW four-stroke engine
4) $22,000 without engine.

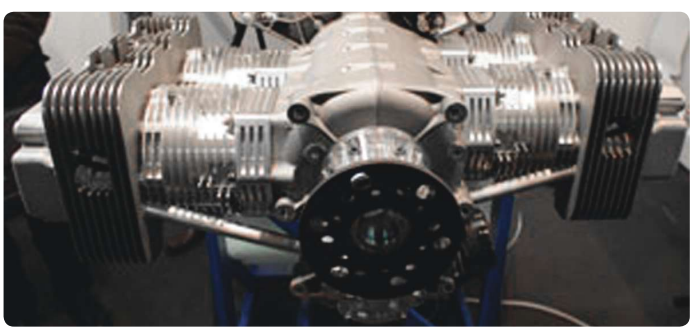
Belite is also developing amphibious floats. Constructed entirely of aluminum, these floats are designed to work with retractable wheels or as straight floats. The straight version will weigh less than 28 pounds. (The FAA allows 30 pounds per float in FAR 103.) For more information, call Belite Enterprises at 316-253-6746, visit www.BeliteAircraft.com, or e-mail info@beliteaircraft.com.



Italian Manufacturer Unveils Experimental Powerplant

Another aviation engine has emerged from Italy—the Egimotors EGM4x4, introduced February 2 in Modena, Italy. The 4.5-liter EGM4x4 is a direct-drive, four-cylinder flat engine (112 millimeter x 100 millimeter bore/stroke) with four valves per cylinder. Power output ranges from 140 hp at 2,500 rpm to 280 hp at 5,000 rpm. Dry weight is 195 pounds as designed for "rough helicopter use," but it will soon be lightened so that the serial production, bolt-on, wet weight for airplane use will be less than 220 pounds. Weight will include the external oil tank, oil, and oil cooler.

The EGM4x4 engine is air- and oil-cooled; the cylinders and cylinder heads are externally air-cooled while engine oil from the dry-sump crankcase is siphoned by a dedicated scavenging oil pump and fed through an oil cooler before coming to the external oil tank. From there, oil is sent to the engine pressurized by a second high-pressure oil pump. Oil pumps are engine driven and sit on both sides of the camshaft, located below the crankshaft.



The EGM4x4 has four single aluminum cylinders coated internally with nickel-silicon. Nonmoving, outer, visible engine parts are aluminum while internal parts are steel. Two cylinders on each side share a single cylinder head. The four valves per cylinder are actuated via camshaft rods from the central camshaft.

Two redundant engine control units (ECUs) drive two independent ignition and fuel supply systems. The engine has two fuel injectors per cylinder, each system working up to 50 percent capacity; if one malfunctions, the other takes over to supply full fuel. The EGM4x4 can be run either on 95 octane auto fuel or on 100LL avgas.

While pricing has not been published, an Egimotors spokesman revealed a firewall-forward airplane install for the 140/160-hp version would likely be at $22,700. The helicopter version would be approximately $24,000. For more information, visit www.Egimotors-Engines.com. … by Marino Boric EAA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When Is a Cozy III *Not* a Cozy III?

When it's built by Dennis Butler

By Budd Davisson

Just about everyone at EAA AirVenture Oshkosh 2012 was doing Dennis Butler of Houston, Texas, a disservice by referring to his Cozy III (more precisely a IIIP) as an "enlarged Cozy III," even though that's what he calls it himself.

Most people don't take into consideration that when you grow an airplane from a two-place to a three-place-plus and enlarge it 10 percent overall, what you get is a totally new airplane; very little from the original design transfers directly. So, what we should be crediting Dennis with is not building a modified Cozy, but rather creating his own design within the Cozy format. This is far from being as easy as it first appears.

Born and raised in Boston, Massachusetts, Dennis, EAA 300656, was into technology and building early in his life, and when he graduated from Boston Technical High School, he went directly into the Air Force.

"When I got out of the Air Force, I went to University of Massachusetts in Boston and got a degree in physics," he said. "Then I went on to the University of California and got a Ph.D. in astronomy and astrophysics."

Photography courtesy Dennis Butler

The highly reflective finish of Dennis' Cozy IIIP resulted from two coats of clear top-coat, with half of the final coat sanded away with 1500, then 2000 grit wet sandpaper. This was followed by buffing with two successively finer grades of buffing compound.

Obviously drawn to space flight, he found the perfect slot in Houston working on the Space Shuttle; when that program ended, he found an even better gig. He explained, "I'm now working on the Dream Chaser space plane. It's closer to being an airplane than a rocket and can land on any large commercial airport. It's a fun project!"

While most pilots can trace their interest in flying to a specific event, Dennis can't. "It's just one of those things that has always been there," he said. "I learned to fly in the usual Cessna stuff and discovered *Sport Aviation* in the early 1980s."

One fact that certainly separates him from the rest of the sport aviation herd is that he didn't attend EAA Oshkosh until he'd already started building his Cozy. (We don't know what else to call it.)

He said, "My dad was a carpenter, so I grew up knowing that building something is really just a matter of knowing what needs to be done and learning the applicable skills. I looked around and saw that a lot of people build airplanes, and it appeared to be something where you read books and watch videos and then go do it."

He makes it sound easy, but if you think about it, he's right: Figure out what needs to be done and learn how to do it.

"While I was working on the Space Shuttle, a friend there mentioned [Burt] Rutan and, as he phrased it, his strange airplanes," Dennis said. "I was initially attracted to the Long-EZ, but at the time it wasn't readily available. However, Nat Puffer was doing the Cozy, and he was well along with producing plans. Unfortunately, it was just too small, and Nat swore up and down that he wasn't going to do a four-place. But I wanted at least a three-place and more room. So I figured I'd start where Nat left off and redesign the Cozy to be what I wanted it to be. Of course, Nat eventually came out with the four-place Mk. IV, but by that time I was so far into my project, I wasn't going to change direction."

Although Dennis was highly educated and could talk about astrophysics and space flight with ease, that wasn't going to help him much in redesigning the composite structure of the Cozy. Significant changes were needed to handle more people and the structural requirements the 10-percent larger size was going to demand. So, what did he do? He read some books and sought advice from friends, just like any other successful homebuilder.

"Mostly, I used the *Modern Aircraft Design* text by Martin Hollmann," he said. "I first validated his algorithms by applying them to the Cozy III and verifying that the spar sizing and other critical structural elements matched the Cozy III plans. That gave me confidence to use Hollmann's

algorithms to extrapolate to a 10-percent bigger airplane, while preserving the original structural margins of the standard Cozy III.

"I also used as much Brock-produced Cozy III hardware as I could. For example, bell cranks, torque tube inserts, nose strut mounting hardware, heavy-duty nose wheel and pivot structure all came from the Cozy.

"My goal was to enlarge the aircraft 10 percent in all areas, including the cockpit, which went from 38 to 42 inches. To do the rest of the airplane, I built a huge pantograph and mounted it on an old ping-pong table. For those not familiar, a pantograph is a very simple mechanical device used to trace a drawing and produce a scaled version of the drawing; it was invented about 400 years ago, and the original design concept worked fine. The scaling is set by varying the length and pivot points of the arms."

Quite often, homebuilders are more or less isolated and have to make an effort to seek out knowledgeable help. Dennis, however, didn't have that problem.

"Jim Voss lived almost across the street from me, and he was building a Long-EZ," Dennis said. "Not only that, but he was an EAA technical counselor and flight advisor; so that gave me firsthand knowledge of how the structure worked, and he was there to help me when I was stuck. He was invaluable in so many ways.

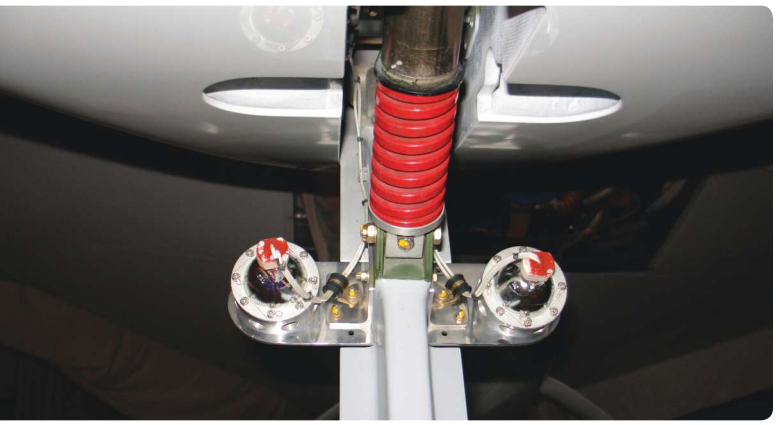
"As I laid out the rear of the fuselage, I made some changes because I was never happy with the way the Cozy not only looked in that area, but also I was certain the airflow wasn't optimal for a pusher prop. So I straightened everything out and made it into a boat tail where the bottom was as long as possible. I shortened the top of the cowling because I wanted the hot air flowing over the engine to cool before exiting. The whole design was aimed at decreasing the back pressure the prop presented at the cooling air exits.

"When it came to the canopy, I was originally going to have one made, but I lucked out and was able to modify a Mk. IV Cozy canopy/windshield that I bonded into a frame of my design. However, I didn't like the rear windows and wanted much more visibility. So I made a male form with the intent of heating a sheet of cast acrylic and draping it over the mold. I built an oven and heated it with two electric tent heaters. I had the material laying on the mold and stood there watching as it got hotter and hotter, but nothing was happening. Nothing! Then, almost without warning, it suddenly relaxed and flowed perfectly down over the form. It

The aft end of lower boat-tail cowl was extended as far back as possible to minimize curvature and reduce airflow separation. Aft end of upper cowl was cut as far forward as possible to allow relatively unimpeded engine cooling air to exit.

Lots of room inside, with ultra-leather covering Tempur foam seats, back rests, and head rests. The small leather pouch located between the seats contains the crank used to lower the nose gear if the electric deploy/retract mechanism were to fail.

Photography by Jim Raeder



Combination landing and taxi lights mounted on the retractable nose gear strut. Both are outdoor halogen types; one of the lights produces a broad beam and is aimed low; the other produces a narrow beam and is aimed higher to provide good illumination near and far.

The inside view of lower cowl showing thin forward and aft stiffeners, a one-inch thick airfoil on the lower inlet lip, heat shields, and cooling air deflectors to promote even cylinder cooling. The heat shields consist of one layer of fiberfrax insulation bonded to the cowl with high temperature RTV, covered by a layer of heat reflective material that is used in firefighter's suits. The combination works very well.

The instrument panel is an all-composite foam sandwich, with 1/8 inch of foam removed from the perimeters of the holes, and the resulting troughs filled with flox and covered with peel ply for increased strength and an attractive appearance.

took so long that I didn't think it was going to work, so if I have to do that kind of thing again, I'll use a couple of propane heaters."

Even though his airplane was primarily a composite design, there are lots of places where steel was used; the most obvious of those is the motor mount. As with the rest of the airplane, Dennis wanted to do it himself. So, rather than just tack-welding the tubing together and taking it to a professional to have it welded, he opted to learn how to weld and do it himself.

He said, "I took the basic welding course at College of the Mainland in Texas City. Then second term, took the TIG course, and in the third term I built the engine mount. I found I really enjoyed learning to weld and have found a lot of use for it since taking the course. It's really satisfying to look at something like a motor mount and know that you built it yourself. It's simply amazing how many different skills you pick up in the course of building an airplane."

But even Dennis Butler has his limits in the do-it-yourself arena, and he drew the line when it came to the propeller. He, like most, decided that was one area he'd leave to the pros.

"It was recommended that I talk to Frank Johnson at Performance Propellers USA in Donie, Texas," Dennis said. "I told Frank what I'd be using for power and what kind of performance I was expecting. Now that I have a lot of time on the airplane, it's obvious that he hit the pitch and diameter right on the nose first time out. Plus, it's a really nice-looking piece of work. I'm often asked how many laminations are in it, and I reply, 'Lots.' I suppose I should count them someday, but I haven't yet. All I know is that it works really well." That beautiful two-blade sculpture is pushing a new AeroSport IO-360-B1B ahead of it.

Dennis explained, "AeroSport engines are assembled using mostly new components for the sport aviation market. I opted for the fuel-injected 9:1 O-360-B1B, which gives 180 hp. I kept the installation light by using a B&C starter and a 40-amp Nippon alternator. The battery is a recombinant gas unit, and the four-stack exhaust is from custom aircraft."

Putting a retractable gear in any airplane is a challenge both in the design and engineering, which didn't bother Dennis a bit. It was just another challenge.

"The airplane is a bit of a 'mutt,'" he explained. "I needed a longer nose strut, so I used the nose strut from an

ERacer; it is a couple of inches longer than the one for the standard Cozy III and gives me a small positive angle of attack during the takeoff run. I used the stock main gear strut for the standard Cozy III but did not trim the length, and I used additional buildups to support a 2,000-pound airplane. The main wheels and brakes are heavy-duty Cleveland parts that Nat later recommended for the Cozy III."

Often the most laborious aspect of building any airplane is getting the surface prepped for painting, and then the painting itself.

"I used a modified Cory Bird technique for finishing," Dennis said. "His technique was to do the finish contouring per Rutan, then apply five coats of epoxy one at a time, each one cured to the tacky stage and squeegeed into all of the pinholes and grooves. After the final coat cured, he sanded to a very smooth surface and then painted. I did the same thing but wet-sanded the final surface to 320 grit before applying primer and doing the final contouring. From that point on, I followed the advice of Mike Huff, a highly skilled professional painter, who recommended the paint products and did the spraying for me.

"We primed the airplane with several coats of PPG K38, as required, and sanded it. The base coat was PPG Deltron 2000 DBC, and we covered that with PPG D890 clear. He did two coats, then color-sanded with 1500 grit followed by 2000 wet sandpaper. After the wet sanding, Mike buffed out the final finish with two grades of buffing compound."

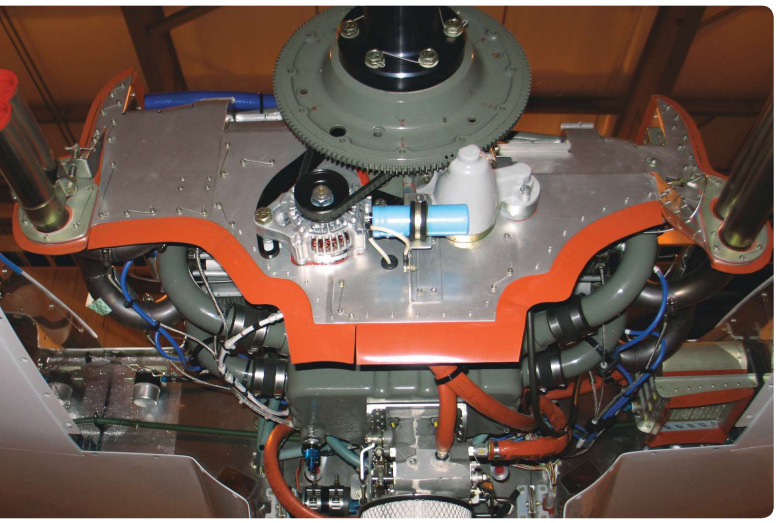
When it came time to fly the airplane for the first time, Dennis had to make the same decision every homebuilder makes: Do I fly it myself or get someone else to do the testing?

"Against the advice of just about everybody I know," Dennis said, "I did the first flights because I didn't want to put a friend at risk. Instead, I progressed through a series of 'baby steps,' beginning with attending the EAA SportAir Workshop 'Test Flying Your Project,' and studying the FAA Advisory Circular *Amateur-Built Aircraft and Ultralight Flight Testing Handbook*."

Dennis's approach to doing the test flying himself could easily be used as a template for others who are considering doing the same thing. "I had not flown very much during the final few years of building, so I worked with a flight instructor to regain proficiency in both low-wing and high-wing airplanes," he said. "We practiced some of the techniques that I would use during both taxi and flight testing. Following that, Ken Cameron helped greatly by allowing me to do a few touch-and-goes with him in his Cozy III. My EAA technical counselor and flight advisor,

Dennis Butler with his Cozy IIIP and the Gold Lindy for the grand champion plans-built award at EAA Oshkosh AirVenture 2012.

Photography courtesy Dennis Butler



Details of engine baffling and exhaust pipe cooling air seals. The oil cooler (lower right corner of picture) is mounted to the aft face of the center section spar with composite brackets epoxied to the spar. The composite brackets serve as anchor points for the aluminum arms to which the cooler is attached.

Jim Voss, was especially helpful in making my first flight as safe as it could possibly be.

"My first flight went very well, with only one relatively small squawk. Although I had plenty of pitch authority, the pitch trim system that I had designed was not very good; it required constant stick pressure during flight. After using stiffer springs and redesigning the system with a more favorable mechanical geometry, I was able to do fully trimmed, hands-off flight."

After putting more than 160 hours on it, including four long cross-countries, including one to EAA AirVenture Oshkosh 2012, Dennis is now in a position to evaluate its handling in all areas.

"The airplane flies great!" he said. "It is fast, stable, and reasonably responsive in both pitch and roll. I have to be careful with the rudders, especially close to the ground, since they are more powerful than I expected. Other than that, the flying characteristics are very similar to those published for the Cozy IV. Takeoffs and landings are a little different than they are in conventional airplanes because I am overly conscious of my limited propeller and winglet ground clearance. They dictate using a flatter attitude on takeoff and landing than flown in conventional airplanes. I avoid wing-low crosswind landings to protect the lower winglets. Instead I use a crabbed approach, with a little rudder to straighten out just before touchdown. These procedures are per Nat Puffer's recommendations in the Cozy III POH.

"At altitude I'm cruising at 171 knots and 8 gph. I'm using 80 knots on downwind, deploy speed brake, when abeam the numbers, then hold 75 knots on final and over the fence. I touch down at 70 knots. The airplane is very solid at that speed. It is, however, a pavement-only airplane because the front gear and strut are not designed for unpaved runways."

No one who builds an airplane is happy with its final empty weight, and Dennis is no exception.

"Empty weight is 1,320 pounds," he said. "My design target was 1,250, but I blew that when I added 20 pounds of paint and 50 pounds of Tempur foam seats and upholstery. No complaints, though. Those seats, with ultra leather upholstery, are extremely comfortable and nice looking, too. Useful load is 680 pounds.

"For fuel, I have 25 gallons useful each side for a total of 50 gallons. At economy cruise of 150 knots, fuel burn is 7 gph with the mixture set to 50 degrees lean of peak. This makes six-hour flight legs possible, but that's much longer than I like to fly without stopping to stretch my legs."

No airplane is ever perfect, and it's often after flying it for a while that you realize there are some things you'd change if building it again.

Dennis said, "A friend built a Legacy with an all-glass cockpit, and if I were to do it again, I'd go that way. Although, since I started building in 1990, the instrumentation available to the sport aviation market has progressed wildly.

"Another change I'd make would be to make the bottom of the winglets easily replaceable, streamlined wooden tips because they sometimes get scraped. I may yet do that."

Just as no homebuilt aircraft is ever truly completed, no homebuilder is ever done building or looking for new projects. In Dennis's view that means, as Thoreau said, "Simplify, simplify." Dennis said, "The next thing I want to do is fly a Cub."

How's that for extremes? Now we just have to watch to see whether he's going to be happy just flying a Cub. Do we see another building project in his future? EAA

Budd Davisson is an aeronautical engineer, has flown more than 300 different types, and has published four books and more than 4,000 articles. He is editor-in-chief of Flight Journal magazine and a flight instructor primarily in Pitts/tailwheel aircraft. Visit him on *www.AirBum.com*.

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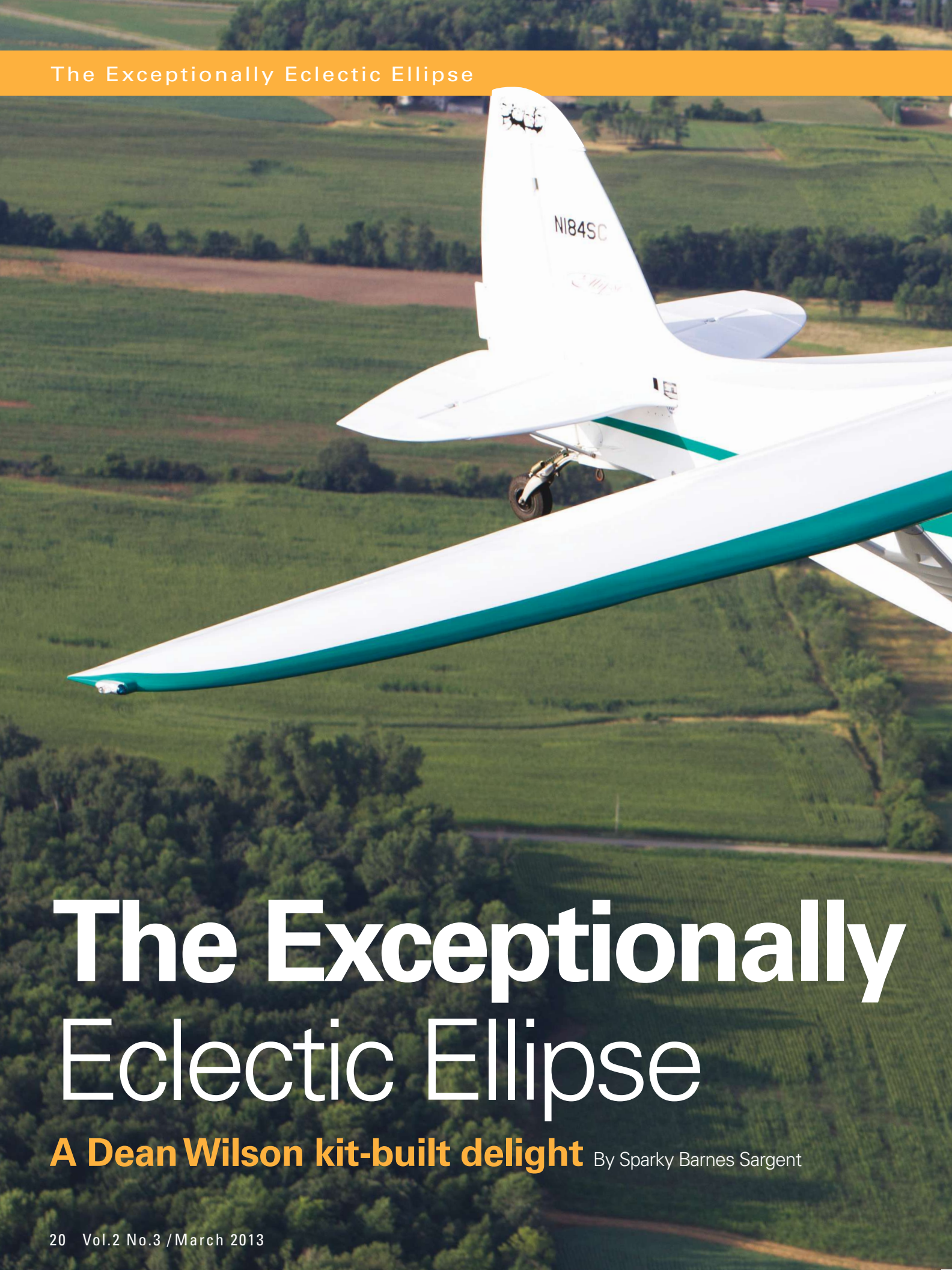


The Exceptionally Eclectic Ellipse

A Dean Wilson kit-built delight

By Sparky Barnes Sargent

Scott Christiansen of Rapid City, South Dakota, has flown to the annual EAA fly-in convention every year since he was 18 years old—44 years and counting. He's a pilot and builder who has a yen for rather rare experimental amateur-built aircraft. He flew his Piel Beryl for 30 of those years (N114SC, featured in *Sport Aviation*, April 2002). For the past three years, he's been flying his four-place Ellipse (N184SC), which he completed in January 2010.

The Designer and Design

The remarkable Ellipse was the product of prolific aircraft designer Dean Wilson, who was inducted into the EAA Homebuilders Hall of Fame in 2010. Dean is perhaps especially well known for his Eagle agricultural biplane (type certificated) and the Avid Flyer (kit-built).

The prototype Ellipse was a four-place aircraft that could fly 150 mph with a 150-hp engine. With a 36-foot folding wingspan, it could easily be towed and stored in a single-car garage. At least two additional kits were produced by the company in Grangeville, Idaho.

"The prototype, Serial Number 1, is thought to be in France, though it's still registered to Dean Wilson [N8069X], and Number 2 doesn't seem to exist," Scott

Photography by Phil High

said. "But I've been to the old manufacturing hangar and have seen hundreds of jigs and miscellaneous completed parts, which may have been for Number 2. Number 3 had a 160-hp engine, and a friend of mine bought it after seeing mine [Number 4]. So our two Ellipses were in Rapid City, South Dakota, for a long time. He sold Number 3 in mid-2010, and I shared detailed photographs and information with the new owner, Mike Hauger of Idaho, who began actively working on it. His Ellipse [N522H] started flying in the spring of 2011."

Genesis of N184SC

When Scott bought the project in 2003, it was still in the same condition as when it was first purchased from Dean in 1998, when the company was shutting down. The wings, ailerons, and flaps had been skinned with plywood; the steel tube fuselage and vertical stabilizer had been powder coated, and the steel tail surfaces were finish welded. The wings came attached to the fuselage, and Scott did not remove them until he had thoroughly tested the folding mechanism for clearances—and found that the wing root had to be trimmed to match the fuselage contours.

"The wings still required filling and shaping along the leading edges," Scott said, "and the trailing edges where the flaps and ailerons met had to be trimmed so that they could have unobstructed movement. It took hours of test fitting to make sure clearances were there. I touched base with Dean early in the project, just to see if there were any plans or three-view drawings available, but there weren't—so I basically had to figure it all out. It took me thousands of hours to complete the airplane; and part of that is my own fault, because I'm so meticulous."

Elliptical Wings

One of the challenges that Scott encountered was installing the fabric around all of the Ellipse's compound curves. "There are not only outside curves but also in-

Scott equipped his Ellipse with traditional round gauges--his preference, but made sure the interior was beautifully finished.

Scott's four-place Ellipse is powered by a 180-hp Lycoming engine.

side curves as well," he explained, "and anytime you're doing fabric work around an inside curve, there's a lot of snipping or heat shrinking of the fabric before you glue it down. The whole airplane is fabric covered with the Poly-Fiber process and finished in Poly-Tone, including the wood-skinned wings."

The elliptical wings can quickly and easily be folded aft, and the streamlined wing struts neatly conform to the contoured side of the fuselage. First, the turtle deck section must be removed, via quick-release cam locks (since the flaps fold into that area), and then the front spar pins are disengaged. The push-pull ailerons automatically disconnect when the wings are folded aft and connect when the wings are pinned into flying position. (The cable-operated flaps do not disconnect during wing folding.)

Landing Gear

The project already had a Scott tail wheel and large 8.5 by 6 main tires, which Christiansen retained—though the 6-inch wheels would allow him to easily swap the mains for smaller tires. The steel tube landing gear legs are neatly finished to an airfoil shape with fairings (as are the wing struts). Each gear fairing was initially two long fiberglass strips, which Scott carefully glued to the front and back of the gear legs. "Dean designed everything about this airplane for good forward speed," Scott said, "without having to use a lot of horsepower."

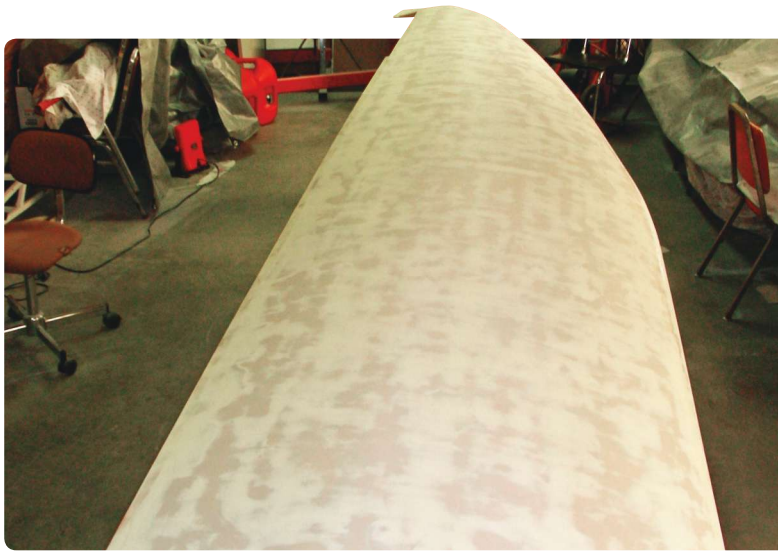
Fire, Fuel, and Prop

Instead of a 150-hp engine like the prototype, this project included a 180-hp Lycoming. Each wing tank holds 18 gallons and feeds a 4.5-gallon header tank, and Scott felt that the 41-gallon total capacity would be adequate for any increased fuel consumption. He decided to install a constant-speed prop, which was an approved combination of prop and engine, so he only had 25 hours of flight-test time instead of the typical 40 hours. Scott said, "It's a Hartzell prop with a scimitar blade, which has the same tapered, curved shape as the wings, so it was just a beautiful match for this airplane."

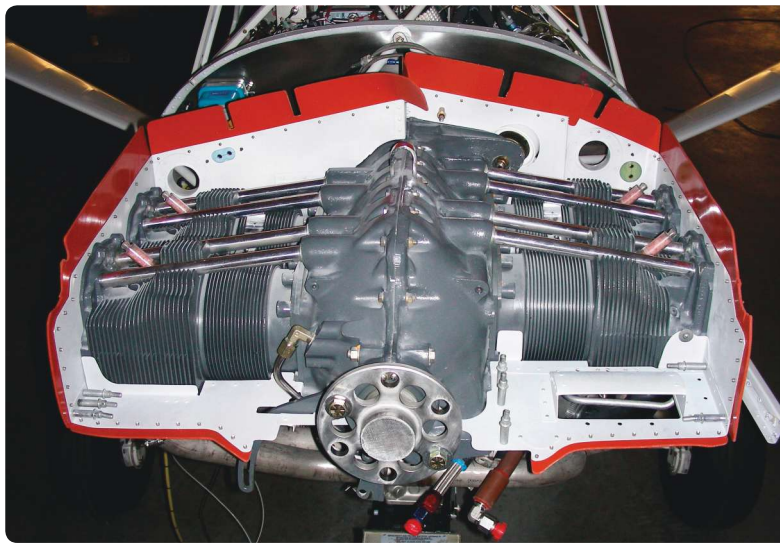
The constant-speed prop required the installation of a prop governor on the engine, and Scott also made a custom prop governor line with a tube bender and stainless-steel tubing, thus ensuring clearance of the dynafocal mount that is unique to this Ellipse and engine.

Scott was concerned about the clearance between the cowling and the spinner, but a 1/8-inch spacer solved the problem. He also worked carefully to ensure that the

The wooden interior being installed inside the steel tube fuselage.



The plywood-skinned wings required a lot of sanding and shaping.



Great care was taken to ensure a precision fit of the baffling.

Photography by Jim Raeder and courtesy Scott Christiansen

Designer Dean Wilson (left) with builder Scott Christiansen and his Ellipse. It's one of four kits ever made. Three are still flying, but S/N 2 was never completed.

engine baffling was a precise fit for the Ellipse's downdraft cooling and front oil cooler.

Weight and Balance

When the Ellipse was just about ready to fly, Scott felt he needed some additional information. "I called Dean because I wanted to get some ideas about flight testing and handling characteristics," Scott said. "He was helpful with that, and I was able to jog his memory about some weight and balance issues. He did say the Ellipse had an extremely long envelope from forward to aft CG; that with the fuel basically on the CG of the aircraft, and the front seats near the CG, only the rear seat and baggage loading were issues when you have more people in the aircraft. It turned out that the weight and balance was perfect the first time it was put on the scales; with one pilot and minimum fuel it was near the forward edge of the CG. As you put more people, baggage, and fuel into the airplane, the CG moves aft toward the rearward CG range. Dean designed a very good airplane."

Flying the Ellipse

One of the first things Scott did was taxi testing, mildly accelerating down the runway on the main gear and gently moving the stick fore and aft in small increments. "It would literally just rock on the landing gear," he recalled, "so pitch control was very effective. Add just a little bit of back pressure, and it flies off the ground at 65 mph, easily climbing at 75 to 85 mph with a 1,500 to 2,000 fpm climb rate, depending upon how slow I want to get it, with flaps of course."

Those flaps are extremely effective, each being 12 feet long with a fairly wide chord. Scott has found "that half-flaps seem to be the ideal position for both takeoff and landing. This airplane is similar to a Piper Pacer with long glider wings; the airfoil changes shape from a laminar flow to a slight camber for about the last six feet of the wing. The wingtip ailerons are small but really effective; I can fly at very low speeds and still have full aileron control. Dean used this same wing design for his crop duster Eagle, which was one of the best ag aircraft out there as far as handling and load carrying."

Scott did have a surprise on the very first flight when he discovered that he had to hold heavy right rudder—but he quickly determined that it was because the ailerons and flaps needed rigging. Despite that, he immediately liked the way it handled. "After retracting flaps, the Ellipse accelerates above 100 mph quite easily and has a cruise climb of 110 or 115 mph indicated, while maintaining a climb of 500 to 1,000 fpm," Scott said. "I did the flight testing at 75 percent power because I was breaking in the engine; so it was always 2400 rpm at around 24 inches of manifold pressure."

The Ellipse was initially showing about 145 mph cruise, but it improved after Scott worked on the rigging and got the ailerons to fly in trail with the flaps. Scott said that turned out to be a rather complicated process, which didn't yield the desired results until after 70 hours of flight time. "Every time I would make an adjustment, I would go out and fly for 15 minutes to see if it needed more adjustment or if I had to take out what I'd just put in. One control adjustment might change three other items in the handling of the aircraft, and you wouldn't know it until you went up to test-fly it."

Landings took a little while to finesse because Scott was used to flying his tandem Beryl, and the sight picture was different in the side-by-side Ellipse. He typically does a full-stall landing since pitch control is a bit sensitive for wheel landings. "I do have an angle of attack indicator that has been a help for landing approaches. And I've found that as soon as I touch down for wheel landings, with those big tires and bungee cord shock absorbers, I want to make sure to give it a little bit of down elevator, or else the airplane tends to bounce back in the air."

He added, "It will slow flight in ground effect so nicely with those long wings! Overall, I'm very pleased with the Ellipse and its handling characteristics. It burns anywhere from 8.5 to 9.5 gallons an hour while cruising anywhere from 140 to 145 mph, for around 4 hours of flight time plus reserve."

Thoughtfully Designed Features

Scott said, "The control system design is excellent; there's extreme use of adjustable rod ends and push-pull controls. Plus, every aspect is adjustable—you can bring the rudder pedals closer to you if necessary, and you can move the seats fore and aft within a 4-inch range."

Another nice system is the spring-loaded elevator. "Whenever you change the electrically operated trim on the stabilizer, your stick pressures are always the same, and that is just fantastic," Scott said. "I didn't want a mechanical trim indicator, so I adapted a flap position indicator with a gauge on the instrument panel."

The Ellipse is a sweet combination of form and function, especially with its large cargo area behind the rear seats. "I'm sure you could carry all the camping gear you'd ever want, and I can easily carry over 800 pounds in the airplane," Scott said. He enjoys camping with his airplane at Oshkosh.

Visibility is another enhanced feature of the Ellipse. Scott fabricated nice large windows from Plexiglas, and the windshield from a piece of Lexan. "Visibility out of the airplane is fantastic," he said, "and I decided to add a skylight above the front seats, which also makes the cabin feel even roomier."

Young Eagles

Scott loves flying his Ellipse and likes to share that joy with others. "I've flown many Young Eagle flights with EAA Chapter 39," he said. "I can fly three at a time; and it's a neat experience because young children are always asking questions that you don't expect, and they really enjoy the flying." Perhaps that's especially true when they have the opportunity to fly in such a unique airplane. EAA

Sparky Barnes Sargent, EAA 499838, holds a commercial glider certificate with private single engine land and sea ratings, and she personally restored her 1948 Piper Vagabond.

Scott says the 12-foot flaps are extremely effective.

Lots of room for baggage. Useful load is 800 pounds.

Photography by Jim Raeder and courtesy Scott Christiansen

Rob's RVX, ready to fly.

X Marks the Spot!
A "combo" RV

By Rob "Smokey" Ray

What do get when you cross an RV-4 with an RV-6? The RVX, as I call it! Over the past 20 years I have been privileged to help build and rebuild three marvelous personal aircraft. Markedly different, but marvelous nonetheless.

High Admission Price

In recent years I have noticed a trend. The rise in the cost of aircraft is double what I spent in 1996 dollars to finish my RV-4. Some instrument panels cost more than my airplane! My HR2 was a rebuild and a wonderful airplane but with a healthy appetite and costly support structure. Flying has to become less expensive, or it will simply become a luxury of the wealthy. Having lived in Japan and having seen its version of GA, or the lack thereof, I can assure you the alternative is gloomy. Ken Krueger and Ken Scott agreed when they built their mini masterpiece, the KK-1. The Onex and Thatcher CX4 all follow this concept.

The Mission?

Why build the X? Mainly to practice what I was preaching and get a cool airplane out of the deal—a low-cost, fun, efficient airplane. Building a viable, efficient, and fun personal machine for low dollars isn't a new idea. Bernard Pietenpol originated the concept, John Thorp perfected it, and Dick Van Grunsven, John Monnett, and others have refined it. So how can you keep costs low, performance high, and investment sound in today's economy? Answer: Scrounge! Yes, you have to shop around, search for used items for some things, new for others, lower your sights on expensive things, and get back to basics.

What is your mission? Do you really think you're going to be shooting an ILS to minimums every day after flying all day on autopilot? I sure don't want to, but this seems to be the current mentality. Do you want to do aerobatics? Do you want to land on grass? How long is your average flight? Do you really need an IO-360 and constant-speed prop? Do you need an autopilot, dual electronic flight information system, and Bose stereo? Would you like to burn mogas when and if 100LL goes away? When it really gets down to it, you don't need much fluff to have fun. The lighter the weight, the better they fly.

Getting Started

The X began as a search for RV projects from which to assemble and build a very low-cost, efficient, "fastback" RV-4. After purchasing a project through Cornerstone Ministries, the X began taking form. My costs started with the engine. With some searching I was able to find and rebuild an O-320A for a total expenditure of $6,500. I have always liked the "A" as it is slightly lighter and less costly than other O-320s and has a hollow crank if a constant speed prop becomes an option later. The prop with extension was $1,800. Panel? The MGL Enigma at $1,500 was a bargain when you looked at total capabilities and future growth potential. Interior appointments? Paint is all you need, and it weighs little if you keep it to one coat. Exterior paint? Keep it simple. One color is plenty. Vinyl graphics are reasonable. Vans Aircraft agrees, all its prototypes have vinyl over solid paint color. I had the luxury of two friends who restore cars help me really put a nice automotive finish on the X. You can, too.

Time Out

Just as the pieces were coming together, 9/11 intervened. My part-time job as an F-16 pilot suddenly became full time, and I was deployed off and on for the next four years. While I was away, my dad and my friend Arvil conspired to combine my RV-4 bits with an RV-6 fuselage to complete what would become a very cool airplane. This required rejigging the wing, removing one center section bay, and attaching and RV-4 empennage to the -6 aft fuselage.

Time to Fly

Upon returning from overseas, I visited Arvil's shop, and behold, the X! It looked slightly different than a stock -6, something I couldn't put my finger on. It was the dimensions, slightly smaller tail, shorter wings, very RV-4-like. Hmmm, I really liked it. Three months

The RVX en route to paint booth in 2008.

A wing and a prayer, coming home from paint booth.

My dad, Robert Ray Sr. and my late friend Arvil Porter gave the X one final look before I made the first flight. Arvil's shop and the end of his 900-foot runway in the background. Arvil helped me immeasurably during the building of my RV-4 and the X.

after all the ground testing completed, nothing was left but the test flight. I taxied out of Arvil's backyard onto his 1,200-foot turf strip between soybean fields, applied max thrust, and I was off. Immediately upon getting airborne I noticed myself slightly overcontrolling the X; in pitch and a bit in roll, *it is sensitive*! Climb was reminiscent of my 150-hp RV-4, and the Catto two-blade fixed-pitch prop was nearly perfectly matched. After several flights to adjust rigging and tweak the engine monitor, the X was settling down as a real performer. The combination of lightweight, tight fairings and the proper prop paid off. We had a winner!

Cost?

All tolled, well under $30,000 out the door. That's still expensive in my book, but less than half the $100,000-plus of the modern RV. Knowing what I know now, I could even do it cheaper the next time around. The bottom line? My 20-year-old RV grin is unblemished, maybe just a bit refined!

Epilogue

Since building and flying the X, I have several new airplane concepts bouncing around my cranium. Originally I wanted to name the X the "RV-5," but Van's actually built one back in the early 1980s. It was a single-place, VW-powered machine that never took off, so to speak. However, I believe the RV-5 concept is sound—a low-cost, efficient airplane for the future. With many new 80- to 100-hp engines now on the market, including the Revmaster, Great Plains VW, AeroVee, ULPower, and Rotax. Lycoming and Continental also have revived their early models into lightweight contenders. Avionics also have come a long way, with the MGL Extreme mini EFIS, Dynon, and others. More aptly, there is an app for that. There is an iPhone app for engine monitoring and even flight instruments. Seats? I believe one or even one-and-a-half, reminiscent of the Sonerai. The KK-1 represents this beautifully, as does the Onex, Thatcher CX4, and BK-1. It's hard to argue the viability, utility, and economy of the Thorp T-18, even with today's push-button quick-build kits. I think the Van's juggernaut could do them all one better with a viable quality kit and engine deals that would bring in even the most skeptical builder. It would have to be more attractive than the current offerings, experimental, and basic. As Forrest Gump once said, "Bubba did have a fine idea"; implementation is the key. Only time will tell. EAA

My RV-4 "The Bandit" that I built partially while stationed overseas.

Scanning the Bearhawk Plans
A time-saving tip

By Ken Scott

Recently, three neighbors and I formed a consortium to scratch-build a Bearhawk LSA. Papers were signed, a bank account established, and soon we received the plans from designer Bob Barrows. Excited, we spread them across the living room floor. There were 29 hand-drawn sheets. Every one of them had the same sentence across the bottom: "Scale drawing for dimensions not shown."

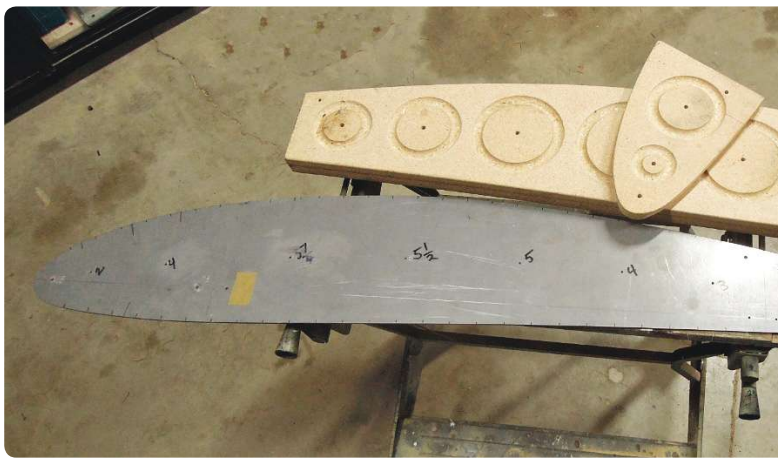
We quickly discovered that quite a lot of dimensions were "not shown." And when dimensions *were* spelled out, the copying process wasn't perfect. Variations of a 1/16 inch or more were common; sometimes just the line width was enough to make a very distinct dimensional difference. In a world where precise computer-aided design (CAD) drawings have become the norm, these seemed, frankly, a little crude.

We found a simple solution that not only gave us fully dimensioned plans but also provided a means of producing parts far more quickly and accurately than chopping them out by hand, one by one. We scanned the plans sheets at a local copy shop, and they did all 29 sheets for $30. The scans were saved as Adobe .pdf files, a file format that is almost universal in the computer world. Adam, one of the CAD hobbits who inhabit the far nooks of my workplace, opened the files in his drafting program (SolidWorks in this case, although almost any simple mechanical drawing program would work), and in an hour of simple tracing and dimensioning, produced very accurate CAD files for several parts. Using called-out dimensions, the program could instantly deduce the rest—"If *that's* given as 0.625 inch, then *this* has to be 0.500 inch." The CAD drawings traced from the .pdf files were saved as .dxf files.

I don't know what .dxf means, but computer-operated machine tools do. The 5-foot airfoil profile (provided in the plans), scanned and traced in CAD, was laser-cut from a sheet of 3/16-inch steel for $50. We used the steel master as a router template to make form blocks for the main, nose, and rear wing ribs. The total time for scanning, redrawing, laser-cutting the master, and routing the finished set of form blocks out of high-density particle board was about five hours.

Things got better from there. The usual method of producing flat metal parts from Bearhawk plans is to cut out the paper depiction, glue it to the metal with spray adhesive, then cut it out by hand. Instead, we bought an assortment of aluminum remnants from a local aircraft manufacturer. We took the material and .dxf files of several parts to a local business that makes aluminum parts for computer displays. In 15 minutes, its computer-driven mills and punch presses made enough spar fittings for three airplanes. Wing rib blanks were cut from sheet aluminum, complete with lightening holes, in about two minutes per rib, and accurate to about two-thousandths of an inch.

Scanning and reworking the plans in the computer have enabled us to quickly produce inexpensive and accurate parts. If this seems like cheating…well, airplane builders have always used the best tools they could, and we're happy to continue the tradition. EAA



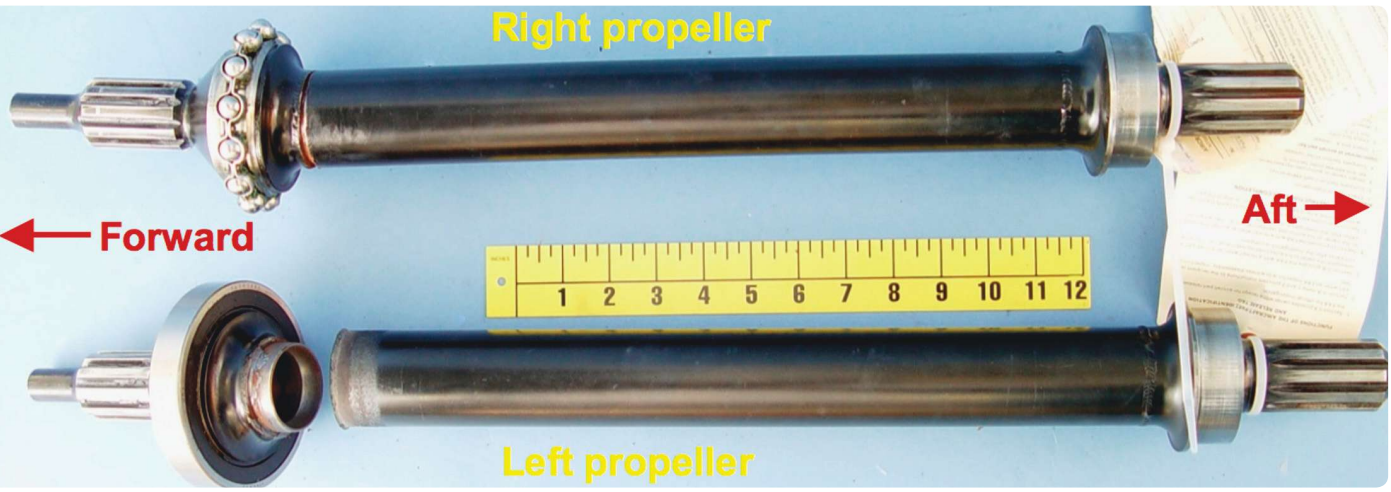


Figure 1—The two fractured propeller shafts, as received. The left side shaft had completely fractured at the forward weld, while the right side shaft was fractured but still attached in the same location.

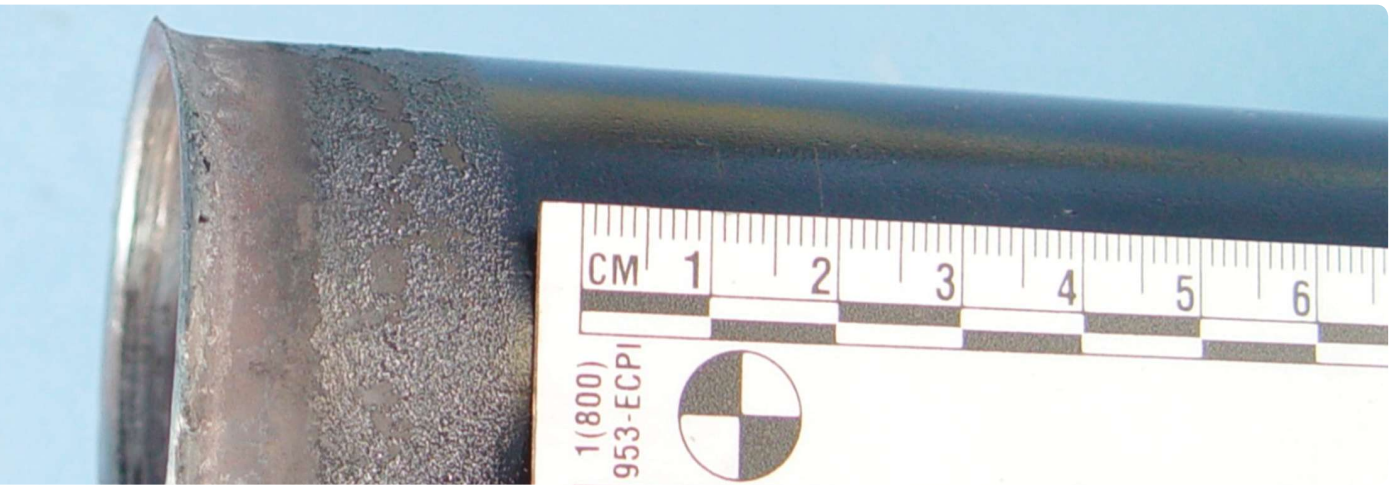


Figure 2—The aft fracture surface of the failed forward weld on the left side propeller shaft tube, as received.

Welds Are Crucial

NTSB [Accident Report] CEN11FA528

Editor's Note: The following report is reprinted from a National Transportation Safety Board review of an accident involving a Wright Flyer Model B that resulted in the death of the two test pilots. Portions of this report not directly related to the cause of the accident have been deleted for the sake of brevity. These deletions are indicated by ellipses (…) in the text.

History of Flight

On July 30, 2011, about 1045 Eastern Daylight Time, a Wright B Flyer experimental amateur-built airplane, N453WB, impacted terrain during a forced landing near Springfield, Ohio. The two commercial pilots sustained fatal injuries. The airplane sustained substantial wing and fuselage damage. The airplane was registered to and operated by Wright B Flyer Inc. under the provisions of 14 Code of Federal Regulations Part 91 as a test flight. Visual flight rules (VFR) conditions prevailed for the flight, which did not operate on a VFR flight plan. The local flight originated from the Springfield-Beckley Municipal Airport (SGH), near Springfield, Ohio, approximately 1008.

The operator's accident report, in part, stated: This experimental airplane was involved in the initial phases of flight testing. Flying qualities, stability, and control, and performance were being tested. Depending on the weather conditions test points were selected from a flight test matrix. The pilots, always two in the aircraft, would brief the flight, fly the test points, and document the results. Depending on how well the test conditions were met the pilots would show that test point as complete and select another test to fly. The morning of the accident the pilots brief was not attended by any other person; exactly what points they were testing is not known.

According to statements given by witnesses in the area, the airplane's engine sounded like its rpm varied. The airplane was observed to be flying slow and to bank to the left and right. One witness reported that the airplane spiraled downward. …

Aircraft Information

N453WB, Serial Number 002, was a plans-built antique replica Wright B Flyer experimental amateur-built airplane. According to the builder's website, the airplane had modern airfoils, conventional ailerons, steel tube structure, and modern aircraft fabric. A four-cylinder, 205-hp Lycoming HIO-360-C1B engine, with Serial Number L-13374-51A, powered the airplane. The airplane was equipped with two chain-driven, counter-rotating, two-blade Sensenich pusher propellers. The airplane had seating for two occupants. The airplane was equipped with dual controls. The airplane had a wingspan of 33 feet 6 inches, a height of 7 feet 8 inches, and a length of 26 feet. The airplane's empty weight was 1,876 pounds, and its gross weight was 2,650 pounds. The demonstrated takeoff speed was listed as 55 mph. The airplane had accumulated 58 hours of total time at the time of the accident and had accumulated 28.8 hours of Phase I flight time. …

Communications

According to a pilot flying inbound to SGH, he made a position report on the SGH common traffic advisory frequency (CTAF), and a pilot representing the Wright B Flyer answered back on the CTAF indicating the Wright B Flyer was in a racetrack pattern at 3,100 feet above mean sea level about three to four miles south of SGH making east-west circuits. The inbound pilot practiced a touch-and-go at SGH and subsequently heard a call that indicated the Wright B Flyer was landing in a field five miles north of SGH. He said the pilot sounded calm. He asked the Wright B Flyer if he could be of any assistance and got no reply. He then heard two garbled transmissions that said something about a "chase car." He flew three to seven miles north of SGH to look for the aircraft based on the radio call.

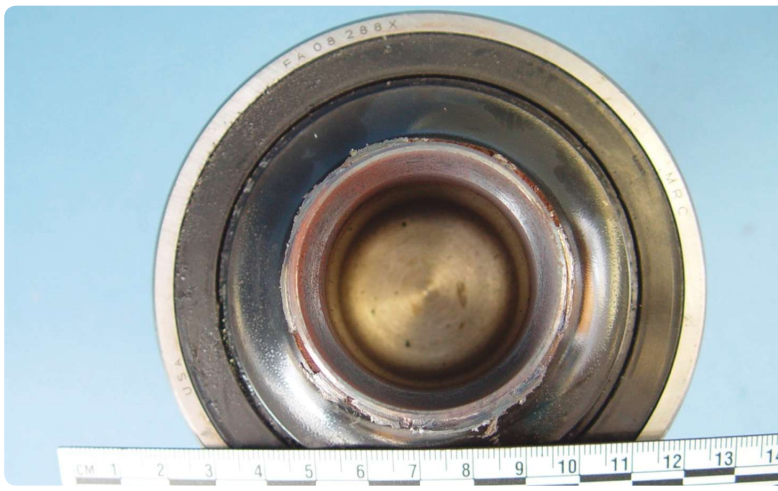


Figure 3—The forward fracture surface of the failed forward weld on the left side propeller shaft tube, as received. This is the mating side of Figure 2.

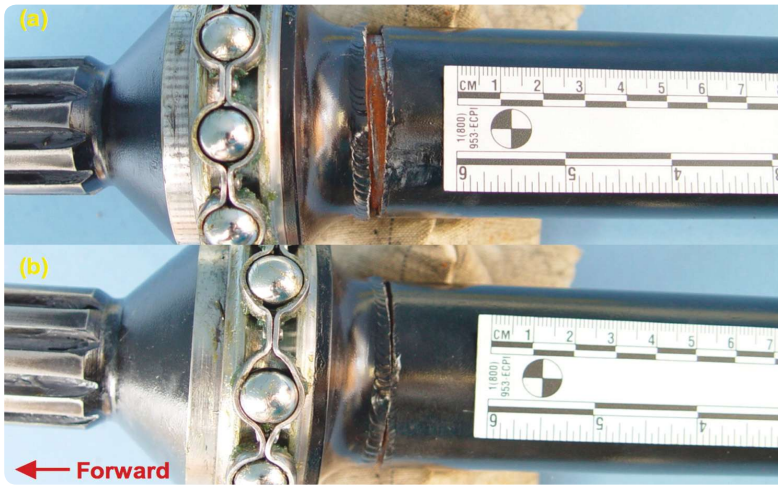


Figure 4—The fractured forward weld of the right side propeller shaft tube assembly, showing (a) a side with complete fracture and (b) the small section still intact.

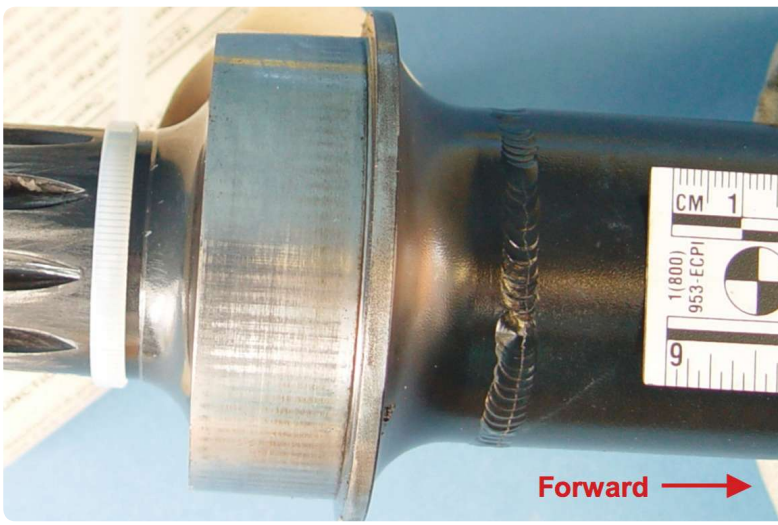


Figure 5—The aft weld of the left propeller shaft, as received, showing a visible crack along the weld line.

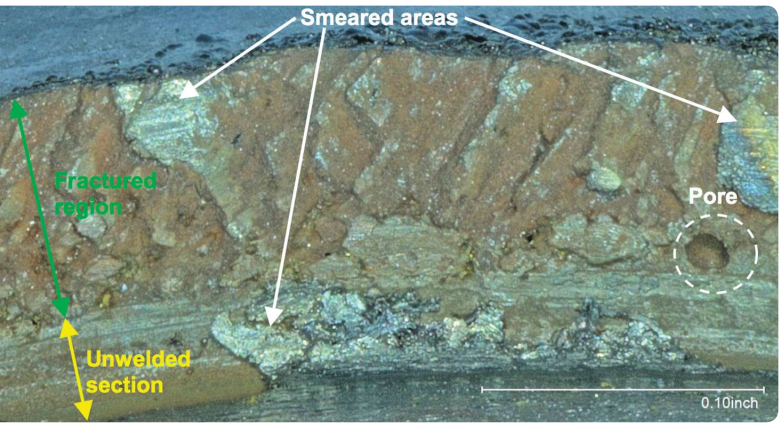


Figure 6—Typical section of the forward side fracture surface of the left side propeller shaft forward weld. The areas of fracture, lack of weld penetration, and smearing damage are labeled. Pores were often found on the fractured areas (~50X magnification).

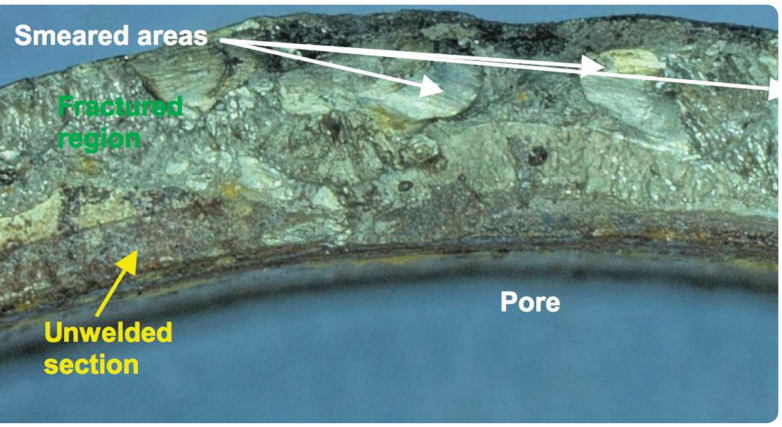


Figure 7—Typical section of the aft side fracture surface of the right side propeller shaft forward weld, after cleaning. The areas of fracture, lack of weld penetration, and smearing damage are labeled. Pores were also present in the fractured areas of this weld (~30X magnification).

Figure 8—Closer view of a typical area of the right side propeller shaft forward weld fracture surface, after cleaning. An area of fatigue could be observed between the unwelded inner area and the rest of the fracture surface.

Flight Recorders

The airplane was equipped with an engine monitor. The airplane's engine monitor and a recovered global positioning system (GPS) device were shipped to the National Transportation Safety Board (NTSB) Recorder Laboratory for readout. A secure data (SD) memory chip from an onboard Contour video camera was located on scene following the recovery of the wreckage, and that SD chip was also shipped to the NTSB Recorder Lab for readout.

The recovered engine monitor was a Dynon EMS-D10 model, Serial Number 001502, which was a cockpit instrument that graphically displayed engine information to the pilot using a six-inch liquid crystal display. The unit can display engine rpm, cylinder head temperature (CHT), exhaust gas temperature (EGT), oil pressure, oil temperature, battery voltage, fuel flow, engine manifold pressure (MAP), fuel pressure, and aircraft fuel quantity. The unit can record that data on a flash memory chip located on its main printed circuit board. This data is typically recorded at a rate of once per second.

The recovered GPS device was a Garmin GPSMAP 196 model, Serial Number 65410637, which was a portable GPS unit equipped with a detachable antenna, and a 320 x 240 12-level grayscale liquid crystal display. The unit was capable of storing date, route of flight, and flight time information for up to 50 individual flights in the form of a flight log. …

The Contour high-definition (HD) video camera was a consumer-grade HD adventurer recorder that was ruggedized and water resistant. It was powered by an internal rechargeable battery and recorded the video and audio information to a removable mini-SD memory card. … This camera was connected to the airplane's audio/intercom panel, and it could record audio alarms, radio conversations, and pilot-to-pilot intercom conversations.

Wreckage and Impact Information

The airplane was located by first responders in a field about one-half mile northwest of the intersection of South Pitchin Road and North River Road. The airplane had a resting magnetic heading of about 210 degrees. The top wing was found displaced forward and deformed downward over the forward portion of the lower wing and engine. The lower forward empennage tubing was buckled, and the empennage was bent downward.

An on-scene examination of the wreckage was conducted. A liquid consistent with the smell of aviation gasoline was found in the bottom of the left fuel tank. The right fuel tank and the header tank were compromised, and no fuel was found in those tanks. The fuel tank selector valve had the

right fuel tank selected. When electric power was applied, the electric fuel pump emitted drops of a liquid consistent with the smell of aviation gasoline. Flight control cables and linkages were traced, and all breaks were consistent with overload. Engine control cables were traced, and all breaks were consistent with overload. The left magneto sustained damage and was not able to be tested. The right magneto sustained damage, and it produced spark from its center electrode when it was rotated. The top spark plugs were removed. The spark plugs were gray in color, and no anomalies were detected. The engine-driven fuel pump was torn off its base.

A disassembly of the engine-driven fuel pump revealed no pre-impact anomalies. The fuel injection distribution valve was disassembled, and no anomalies were detected. The engine exhibited a thumb compression at all cylinders. The fuel servo sustained damage, and its mixture control shaft had separated outboard of its mixture control stop. The hose to the fuel servo screen contained drops of a liquid consistent with the smell of aviation gasoline. The fuel servo screen was free of debris. The oil filter canister was removed, and no debris was observed.

Subsequent to the on-scene examination, the propeller shafts were examined by FAA inspectors, and the left propeller shaft tube exhibited a separation at its aft weld. The left and right propeller shafts were shipped to the NTSB Materials Laboratory for detailed examination. …

Tests and Research

Dynon EMS-D10

According to an NTSB Vehicle Recorder Laboratory Recorded Data Factual Report, the Dynon EFIS-D100 unit sustained major damage from impact forces. An internal inspection was performed, and it was determined that the unit could not be rebuilt for download. …

Garmin GPSMAP 196

According to an NTSB Vehicle Recorder Laboratory Recorded Data Factual Report, the Garmin GPSMAP 196 unit sustained major damage from impact forces, and it was determined that the unit could not be rebuilt for download. …

The GPS unit's data revealed the accident airplane's flight path, and it recorded data until 1044:57 where the last recorded ground speed was 55 knots. The NTSB Vehicle Recorder Laboratory Recorded Data Factual Report is appended to the docket associated with this investigation.

Contour HD Video Camera

The SD memory card was placed in a memory card reader. A 2-megabyte file was recovered from the SD memory

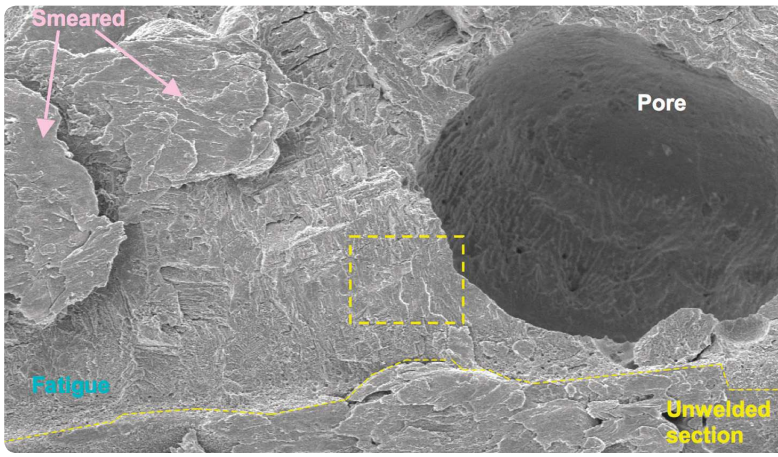


Figure 9—Secondary electron (SE) micrograph of the left propeller shaft fracture surface, showing fatigue striations near a pore defect, after cleaning. The boxed area is shown in Figure 10.

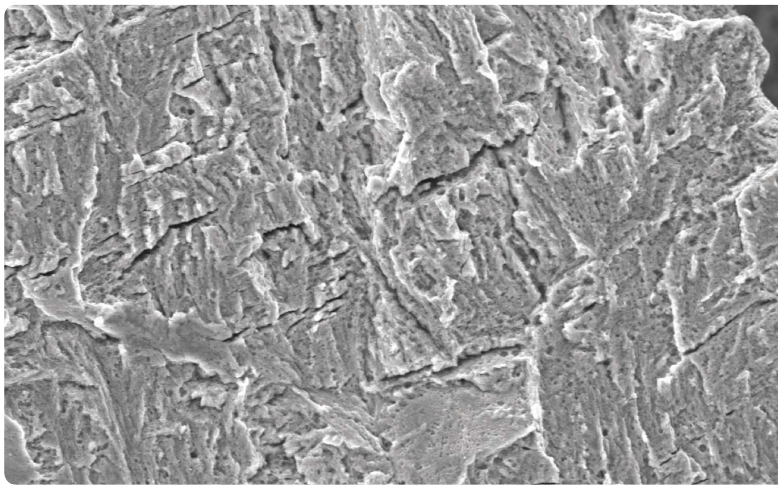


Figure 10—SE micrograph of the boxed area in Figure 9, showing fatigue striations.

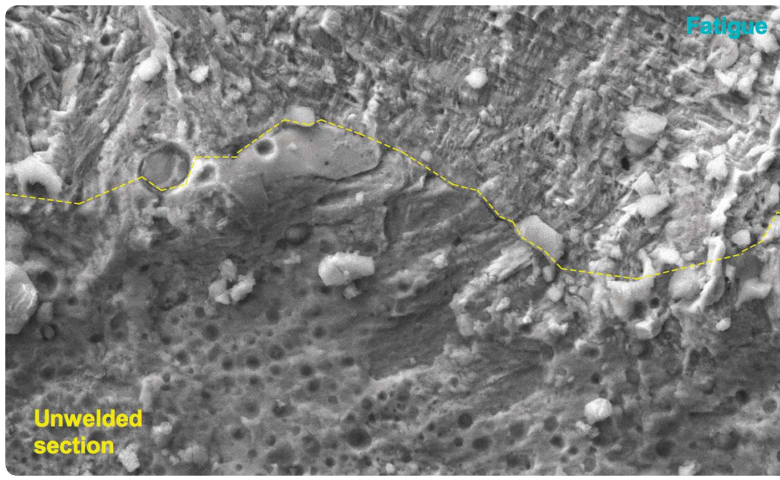


Figure 11—Secondary electron (SE) micrograph of the right propeller shaft fracture surface, showing fatigue striations that developed at the unwelded areas of the forward weld, after cleaning.

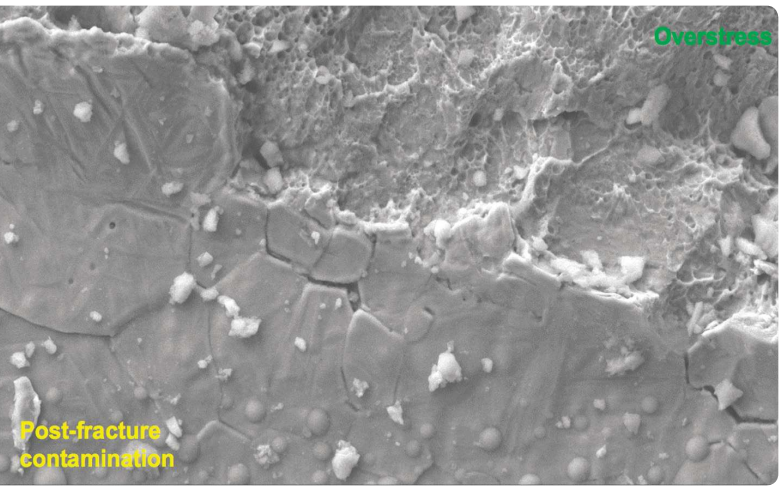


Figure 12—SE micrograph of the right propeller shaft fracture surface, showing areas of overstress and post-fracture surface contamination.

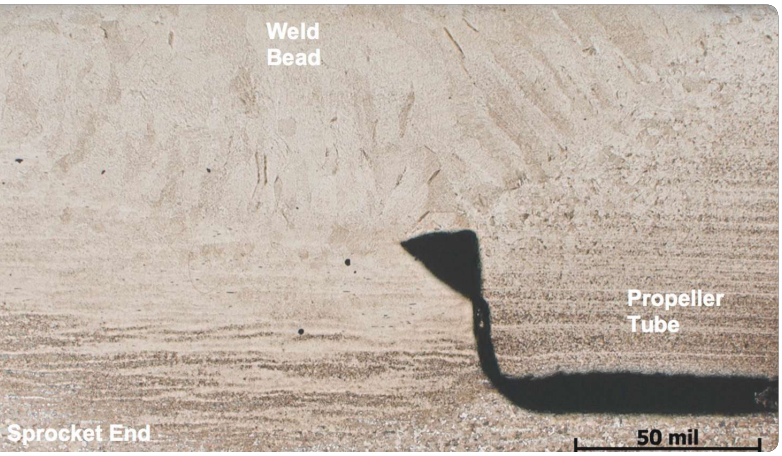


Figure 13—Cross-section of an intact section the right side propeller shaft aft weld, showing the depth of the weld penetration relative to the joint (~25X, etched with 4% Nital).

Figure 14—Cross-section of an cracked section the right side propeller shaft aft weld, showing a crack emanating from a gap that had not been welded (~25X, etched with 4% Nital).

card. The recovered file would not play using either the manufacturer's supplied software or any third-party playback software. It was suspected that the normal file closeout and shutdown process had not occurred consistent with an abrupt stoppage of the recorder. However, several third-party software file recovery programs were used to reconstruct the normal movie file structure. This reconstruction yielded a 51-minute 33-second video and audio file.

The reconstructed file revealed that during the accident flight none of the co-pilot's intercom conversations were audible on the recording. The co-pilot's voice was however heard when he was talking on the aircraft's radio. The pilot's voice appeared to be recorded normally during the flight. The video showed that the airplane yawed near the end of the recorded video. Both pilots were observed to manipulate the controls following the yaw. The video showed that the airplane was controllable after the yaw. The video ended in flight near the location of the accident site. The NTSB Vehicle Recorder Laboratory CVR Study is appended to the docket associated with this investigation.

Propeller Shafts

According to NTSB Materials Laboratory Factual Report Number 12-074, the left propeller shaft had completely separated at its aft weld. The majority of the contact areas of both mating separation surfaces had been obliterated by smearing, which was consistent with rotational rubbing of the fractured faces. The outer tube surface near the left tube's aft separation exhibited paint spalling and general discoloration. These features were not observed on the right propeller shaft tube.

A magnified edge view of the tube separation revealed that approximately 25 to 35 percent of the through thickness of the propeller shaft tube had not been welded to the propeller shaft end. This incomplete weld penetration occurred in the inner areas of the joint. Visible defects, such as pores and voids, were observed in the welded areas.

Other propeller shaft welds from the accident airplane were examined, and they exhibited incomplete weld penetrations. The Materials Laboratory Report is appended to the docket associated with this investigation. . . .

Effective Investigation Techniques

Review of the cockpit video revealed that the airplane yawed near the end of the recorded video. This observation precipitated a follow-up examination of the propeller shafts, which revealed the weld failure. EAA

» The complete text of this report is available online here.

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Asking a seller to remove the valve covers isn't asking too much.

Buying a Used Lycoming

By Tim Kern

Among the most popular engines for experimental amateur-built (E-AB) aircraft are the four-cylinder Lycoming engines of 320 and 360 cubic inches. Their popularity comes from several directions: Their availability in many models means that there is a good engine match for many airframes; their long history of development leads to greater "tribal knowledge" and confidence; and their sheer numbers bode well for low prices.

Their very familiarity, though, can mask or even create some tempting pitfalls. Parts swappers don't always get good results. For example, putting high-compression pistons from a 160-hp "D" model into a 150-hp O-320-E model won't work. There's simply more to swapping parts than that. The O-320-E, with its lower compression, is cheaper for a reason; its iron barrels and narrower nose bearings are adequate to the task of producing that 150 hp. Hot-rodding it won't give you the 10 nominal horses the model difference would, but a new set of rings and a valve job very well might add 10 horsepower to a tired one.

The 320 series, specifically, has a little caveat in that it was made in "wide deck" and "narrow deck" engines. The older narrow deck engines are just fine to use, but their parts are getting scarce. How can you tell? The wide deck engine has an "A" at the end of its serial number; the narrow deck doesn't.

Even close relatives have differences. The notion that a "360 is a 360" isn't even remotely true; there are angle-valve and parallel-valve versions, solid and hollow crankshafts, and a myriad other differences. An old post once available on Primemover.org noted that the O-360-A1A "has a bottom-mounted updraft carburetor, parallel valves, 8.5:1 compression ratio, and produces 180 hp." Yet another post stated, "The IO-360-AIA features a horizontal front-mounted fuel injector, angle valves, 8.7:1 compression ratio, and is rated at 200 hp. The IO-360-A1 also incorporates these design items, which are not included in the O-360: piston cooling nozzles, stronger crankshaft, tongue and groove connecting rods with stretch bolts, tuned intake system, and rotator type intake valves."

The lesson? If you don't know what you're looking at, contact a real expert.

All the engine builders that I talked with for this article said this: Keep the engine close to its original configuration, and don't swap significant parts.

Photography by Tim Kern

Make sure that the engine you are buying is the engine you want. For instance, fuel injection is cool, but it's expensive to maintain. A 200-hp engine sounds like a way neater engine than a 180, but do you need it? True, it's an 11-percent boost on paper, but are you aware that engine nomenclature allows a few horsepower above or below the rating? Are you truly going to need those extra horsepower for which you're spending all that extra money? It's likely that a used engine will make fewer rated horses than a perfectly tuned dyno-run example of a new one, so the difference you see on paper may be very little difference in the air. Are you in a hurry? Are you on amphibious floats on a small mountain lake, or do you typically fly from a sea-level airport with a 6,000-foot runway? All that said, what can you do to make sure you're buying a decent engine?

Whether you plan to use the engine right away or do some work on it, be sure you know what you're getting. Check all the numbers in the documentation against the numbers on the physical items. If you're not getting logs, then you're buying a core.

Be sure the engine complies with all the airworthiness directives (ADs), and if it doesn't, get a better deal. Likewise, check the service bulletins (SBs); if the engine doesn't comply with them, that may be better for you as a bargaining chip, but that doesn't necessarily mean it's a good deal. With this information, you can determine how far the engine is from compliance and how much your minimum outlay for repair and modification should cost.

When was the engine last signed off? An engine that's been sitting on a pallet or even in factory packaging may be unairworthy if it's been sitting long enough, if it wasn't preserved for storage, or if it sat in a harsh environment. And an engine that has been sitting may also no longer comply with ADs and SBs.

When was the engine last flown? What was done to it, either in terms of periodic running or preservation, since then? Why was the engine taken out of service? Check also in the aircraft logbook for any record of off-ramp excursions, prop strikes or damage, gear repairs, flood damage, etc. Often, the airframe repairs that are mentioned can shed light on your engine's history. Did the same mechanic who did the airframe or prop work also service the engine?

Is the engine already in an E-AB? Any gaps in the history are suspect; and logs for E-ABs range from perfect to…well, not so good. What props has the engine turned? Check to see that the props were compatible with the engine model.

Beyond the Paper Trail

What this paper chase won't tell you, though, is how much your likely (or ultimate) cost will be. Your inspection—and that of a qualified mechanic—will go a long way toward knowing what you're buying. In other words, you gotta look inside.

For knowing what to look at, Lycoming's SB 388C is a great guide. Read it before you look at your prospective engine, bring it along as a negotiating tool, and do whatever it says that's within your ability and the circumstances of the buying experience.

If the engine is on a flyable airplane, go flying. Watch the gauges; how fast do the temperature and oil pressures rise? Listen and feel for vibrations. At altitude, sanely test the throttle response from idle through full power and back. Run it awhile at cruise settings. Have a friend watch the exhaust during startup and running. He can listen, too—a lot of sounds are audible on the outside that are lost in the usual cacophony of the cockpit, particularly if you're wearing a headset.

What kind of smoke does the engine produce and when? There's smoke in many colors. Black (or dark grey) smoke comes from a rich mixture; it's often seen on takeoff when the engine's running full rich. It should go away when the mixture is properly managed. Blue (or white) smoke is usually oil. A puff of blue at startup or after a negative-*g* maneuver (or a big bump) is okay; continuous smoking usually comes from wear. Valve guides, stem seals, or the piston rings are the likeliest culprits, and those are problems that must be fixed. Any smoking should prompt a look at the logs. Do the fuel and oil consumption numbers make sense?

Next, look for the obvious. If the engine is still on the airplane, you can learn more. Does the prop look good, or—watch out—is the prop new? Are there telltale marks, burns, drips, cooked-oil stains, or dents in the cowl or baffling? Are all the pieces of "cooling tin" intact and properly fastened? Is the carburetor dripping gasoline, or does it

Damaged camshafts usually mean damaged lifters, too. This means a teardown is needed, where you likely will find other parts that also will need replacement.

Photography courtesy Penn Yan Aero

have deep stains? Is the exhaust system secure and in good shape? How does the air filter look…like it's original from 1974? Don't be satisfied with a peek down the oil-stick hole, either. Insist on enough access to look at everything. But while you have the dipstick out, don't forget to look at it. Is it perfectly clean? That's unusual. Is the end chewed up? Not good. Is there a lot of oil near the fill hole? Why?

Have a look at the donor airplane's interior. Look for lots of oil containers, bags of spark plugs, huge toolboxes with every possible wrench in there, or lots of greasy rags. These could be signs of trouble!

Are there broken fins on the cylinders or heads? Small chips that are ground smooth (but not to the base metal) are probably okay. No matter whether the engine is mounted and running or on a skid, you should perform compression checks on all cylinders and look into all cylinders. Put a bore scope through *both* spark plug holes. Removing the valve covers gives you access to the valve stems. Rotate the engine until the valve is released and wiggle the end of it. Is it loose? Are they all the same "looseness"? (An experienced mechanic knows just the right amount of "loose.") You probably can get permission to check if the pushrods are bent, and you should look. You may also get access to the tappets and cam; if so, take a good look. (On most engines, this requires pulling a jug or two. Expect to pay for that labor.)

If the engine is naked, that's good and bad. You can't do a "hot" compression check or inspect the engine mounts (where sloppy maintenance is a clue to other sloppy maintenance). But you can see everything; use the opportunity. Grab all the accessories, and make sure they're mounted securely and that their fasteners are in good condition. Move the prop hub; end play is always present (check the manual for limits), but side play that you can feel isn't good. Check the magnetos. See what the points look like and check if the rest of the internals—the drives and so on—are in good shape. Spark plug wires are expensive. You want good ones.

Penn Yan put a window in a valve cover, to show how much moisture can accumulate, just from condensation. Frequent use (flying) is the only remedy, though frequent oil changes definitely helps!

If the engine is even lightly covered with grunge, get the owner's permission to clean it. Look for anything unusual; a thick buildup may signal a leak in a seam or oil seal or even a crack. (Remember that cracks don't usually start in the middle of things; look at every edge, every hole, every fastener.) Are the fasteners properly installed with two threads showing through fiber locknuts, and are washers where they belong? Are all fasteners aircraft grade? Is the safety wire on backwards (indicating work by a nonmechanic)?

What is the history of oil changes? Remember that it's not just hours that hurt; condensation and chemical deterioration occur when the engine is quiet, too. Look at the oil screens. Ask if there has been a history of oil analysis (and if there has been, check the serial numbers on the reports against the engine's number).

It's well-understood in the industry that "overhaul" and "rebuild" have no definitive meanings. If your engine has had such attention, look at the parts list for a better idea of what was "overhauled." And on recent factory—and a very few independent—rebuilds of 320, 360, and 540-cubic-inch Lycomings, you may have the newer roller tappets and cam. That's great, but expect to pay for the goodness.

Above all, beware of bargains. If you're buying a suspect engine because it's all you can afford, consider how much it will cost if any of your suspicions—even just one of them—gets confirmed!

Lycoming Tips and Specs You Can Use

A quick read of the Lycoming manual on the O-320 and O-360 yielded some quick specs and tips that you can use to your advantage—from outside the engine.

- Crankshaft end play: 0.026-inch max
- Prop flange max runout TIR: 0.005 (new limit 0.002)
- Fins may be ground down, but never into the base metal.
- Look for evidence of improper tool use.
- Welds on certain parts are okay. "For example, almost any area of a rocker box may be welded, but no part of the cylinder head except the fins may be welded." (*Lycoming Overhaul Manual*, Section 3, Page 2, revised January 1970.) EAA

» More information is available at these websites: *www.PennYanAero.com* and *www.Lycoming.Textron.com*.

Photography courtesy Penn Yan Aero

Copies of the low-cost Aerotrek A220 are "flying off the shelves" as fast as they can build them.

A Look at the 2013 Sebring Expo

What's new in the light-sport aircraft industry

By Dan Grunloh

The 9th annual U.S. Sport Aviation Expo, held January 17 to 20 in Sebring, Florida, was a success according to Expo Director Jana Filip, who added the weather wasn't as kind as last year. Some afternoons were windy, and light rain moved through the area a couple of times, but flying hardly stopped at any time during the four-day event. If the past is any indication, at least 10 percent of all the special light-sport aircraft (S-LSA) that will be sold this year in the United States will have been purchased during the event. If follow-up sales are included, the Sebring event's contribution could rise to nearly 15 percent. The Expo was also a success in other ways. Even the name of the event indicates its focus has a wider scope than just light-sport aircraft (LSA). Amateur-built aircraft were well represented with the displays by Rans, Zenith, and Sonex, which had an indoor presence. Be sure to read the online EAA news story "What's New at Sebring 2013," and check out our photo album on Facebook.

Besides selling airplanes, another important function of the Expo is to promote light-sport aviation to the rest of the aviation community and the general public. It accomplishes this in January when there is little else going on to promote our favorite sport, and nothing did that better than Team Breezer. The group of four matching Breezer LSA, including two flown by high school–age pilots, did

Photography by Dan Grunloh

formation flybys and was a natural attraction for the media. I watched one evening as they taxied out for a performance in somewhat windy conditions with light rain and a low ceiling, and I thought, "What an adventure it must be for those teenagers!" They did a terrific job, and they promote sport aviation every time they fly. The team leader is Mike Zidziunas, who operates a training facility at Lakeland Linder Regional Airport in conjunction with the Central Florida Aerospace Academy, the only high school (125 students) in the United States located entirely on an airport. The Breezer is an all-metal, German-built LSA especially designed as a trainer. It was one of the first 12 LSA approved in the United States, and it is available as a kit or ready-to-fly. Watch a Team Breezer video at BreezerAircraftUSA.com.

Team Breezer, left to right, Mike Zidziunas, Philip Herrington, Angel Castellanos, and Randy Wildman. Castellanos and Herrington are high school students who earned their ratings at Mike's training facility, which is part of the Central Florida Aerospace Academy on Lakeland Linder Regional Airport.

The U.S. Sport Aviation Expo serves as a gateway to the future of light-sport aviation. I enjoyed my first visit.

No Big Shakeout Expected

Many have marveled that in the short seven-year period since S-LSA production and sales began here in the United States, more than 130 different models have been approved. There is a dizzying array of choices. If you include weight-shift trikes and powered parachutes, there are close to 40 different S-LSA manufacturers. Surely that can't continue, and the number will be trimmed as the buying public votes with its wallet. A few manufacturers might drop out when their turn comes for an FAA audit. Even if the plane is well built, the paperwork, testing, parts tracking, and quality control measures must be in place to continue production.

While the expected shakeout may be delayed by the poor economy, I'm beginning to have doubts. The sport plane market has many niches, and the pilots buying for recreational flying have different motives than simply transportation. Your airplane becomes a form of personal expression. Pilots enjoy showing up at the pancake breakfast with something really unique. A small company with low overhead, fewer employees, and a quality product doesn't have to sell dozens of airplanes per year to keep the doors open like a large company does. The conventional general aviation media don't seem to understand this and may have a tendency to think that if a company isn't performing financially like a Cessna or Piper, it isn't a success.

A review of media reports from the Sebring Expo turned up some gloom-and-doom statements about LSA that can best be attributed to bias or faulty information. One writer complaining about the cost of S-LSA noted the Czech-built Aerotrek is at the low end of the range at about $84,000 but added, "They aren't flying off the shelves either." That's because there aren't any on the shelves. The Aerotrek is a hand-crafted, tube-and-fabric LSA with folding wings inspired by the Avid Flyer. Rollison Light Sport Aircraft sells all the Aerotreks it can get, and the wait time is up to six months. The European company that produces the Aerotrek is a small, family-style manufacturer with limited production, half of which comes to North America. Rob Rollison said about half of all Aerotreks sold here are the A220 tail-dragger version.

On the other end of the spectrum, the Tecnam factory in Italy typically has 80 aircraft under construction at any one time, and every aircraft is already assigned to a customer. According to Tecnam representative Phil Solomon, the factory doesn't build for inventory. Neither Aerotrek nor Tecnam (and many others in between) will be cashing in its chips anytime soon because sales

Proving that slow LSA can be fun, former A4 Skyhawk pilot Captain R.V. Anderson displayed his M-Squared Breese powered by an 80-hp HKS 700T turbo engine. It's fitted with every possible STOL enhancement and can fly as slow as 21 mph!

haven't taken off as may have expected before the economic recession.

"Some LSA Have More Avionics Than Most Airliners Flying Today"

Another correspondent complained that the manufacturers put too much expensive, full-featured state-of-the-art avionics in their S-LSA in a race to outdo each other, saying, "These are basically day VFR aircraft." Randy Babbitt (a former FAA administrator), who was the guest speaker for the Light Aircraft Manufacturers Association (LAMA) dinner, said that some of the planes at Sebring have more avionics than "most of the airliners flying today." This is not because manufacturers are foolishly trying to driving the price up. Most manufacturers offer basic, lower-cost models, but few customers buy them. Some are said to be suitable for IFR training, and doubtless some former IFR pilots like to have those familiar flight aids, even if they only fly under VFR rules.

The LSA market may have changed since its beginnings when pilots concerned about their medical were a major source of buyers. A closer look at who was climbing into the cockpits at Sebring last month revealed a lot of people younger than my 65 years. Several were successful professionals in their prime, perhaps with kids out of college, and now looking forward to rewarding themselves with a nice car, boat, motorcycle, or airplane. And

Levil Technologies can put all your flight, engine, and navigation data on your iPad or Android screen.

the latest avionics capabilities are truly dazzling. Even your iPad can be a full-featured instrument panel with the help of Levil Aviation.

During the Thursday night LAMA dinner, Jan Fridrich, the head of LAMA for Europe, shared his analysis of the statistics from the LSA industry, using numbers from the FAA database. He excluded powered parachutes and trikes, so his numbers reflect only fixed-wing airplanes. From 2005 to the present, a total of 2,471 LSA were registered. Analysis by region of origin indicates 37 percent of the airplanes were manufactured in the United States,

Photography by Dan Grunloh

An apparently serious buyer tries on the Tecnam P2008 cockpit.

and 57 percent were from Europe. The remainder came from Australia, South America, India, and elsewhere. The number added each year has stabilized between 250 and 300 airplanes. To put these numbers in perspective, consider that in the 25 years from 1982 to 2007, Cessna, Piper, Grumman, Beech, and Diamond manufactured 2,200 two-place airplanes collectively. The LSA industry added more two-place airplanes in seven years than all the majors built in 25 years, and it did it during the worst economic recession in 75 years. It hardly seems fair to suggest the LSA industry is in "critical condition," as claimed by one aviation editor. The truth is that LSA remains one of the strongest sectors in all of general aviation! For more inside information about the state of the LSA industry, see www.ByDanJohnson.com.

Light Sport is the Poster Child for Self-Governance

Babbitt shared some interesting observations about LSA in his address to the manufacturers at Sebring. He had been an airline pilot for 25 years, served as president of the airline pilots union, and currently works for Southwest Airlines as senior vice president of labor relations. Randy said he first learned about LSA at EAA AirVenture Oshkosh and became fascinated by the technology and enthusiasm. He said, "Light-sport is the inspiration for what we will be doing in the future." Calling light-sport aviation the poster child for self-governance, he explained that due to tight funds in the government, regulators will be a lot more interested in self-governance and the designee approach. He said the LSA safety record is better than any other segment and added the industry should be very proud of what it has accomplished. He closed by saying, "Light-sport puts aviation within the reach of people, making it affordable, so it will fuel the pipeline for pilots who will be needed in the future."

The Sebring Expo was successful in selling airplanes, promoting sport aviation, and providing inspiration for the future of aviation, and it did one more thing. It brought together a group of diehard aviation enthusiasts to exchange ideas, re-establish connections, and get fired up and excited about the coming year of sport aviation. It worked for me because I unexpectedly met some old friends and made some new ones, which made the trip priceless. You should try it next year; the 2014 Expo is set for January 16 to 19. EAA

» Please send your comments and suggestions to dgrunloh@illicom.net.

Dan Grunloh, EAA 173888, is a retired scientist who began flying ultralights and light planes in 1982. He won the 2002 and 2004 U.S. National Microlight Championships in a trike and flew with the U.S. World Team in two FAI World Microlight Championships.

Photography by Dan Grunloh

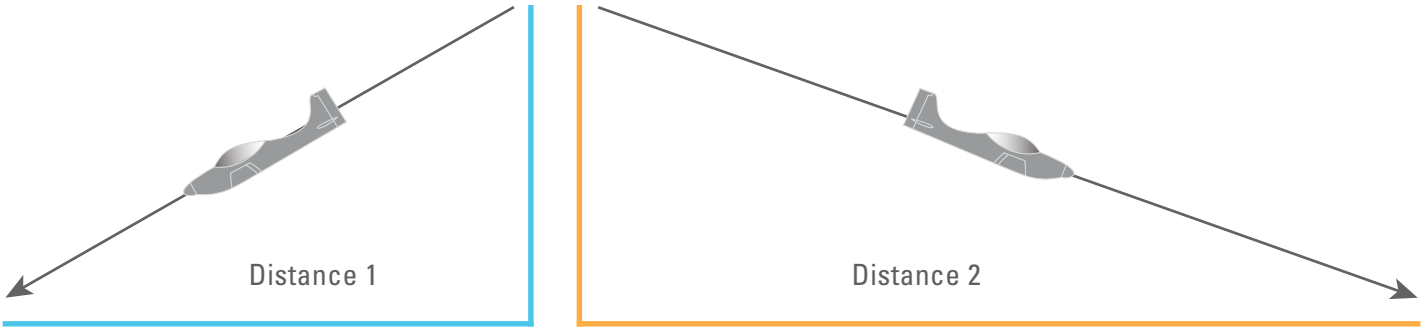


Figure 1

Angle of Attack and Maximum Range

By Ed Kolano

Last month we explained how your airplane's wing always stalls at the same angle of attack (AOA) regardless of its attitude. We used the lift equation and the lift coefficient (C_L) versus AOA curve to illustrate how airplane weight and accelerated maneuvering affect stall speed but not the stall AOA. Using a landing pattern example, we compared the stall protection of an AOA-based final approach with a one-speed-fits-all shortcut or miscalculation of a weight-based approach speed. In short, we attempted to demonstrate the simplicity of using AOA for stall protection.

This month we'll take the AOA discussion to another safety arena—maximum range glide. Yes, a single AOA value will always yield the maximum, no-wind glide distance. Believe it or not, that same AOA will also provide you the maximum cruise range for your airplane.

Glide angle is the difference between your airplane's flight path and the horizontal. If your glide angle is zero, you're flying level. Your airplane would never contact the ground and give you an infinite glide range. If your glide angle is 90 degrees, your airplane is going straight down, and it has a zero glide range. Reality is between these extremes, and the shallower the airplane's glide angle, the farther it will glide.

During an engine-out glide, you can fly an airplane at a variety of glide angles. In Figure 1, both airplanes begin their glide at the same altitude. The airplane on the right has a shallower glide angle, or flight path angle (γ, Greek letter gamma), and therefore travels farther than the other plane.

We did not mention glide speed because how far an airplane glides depends only on its flight path angle. Yes, your airplane has an optimum glide speed that produces the shallowest glide angle, but that speed depends on your plane's weight. Gliding at a speed faster or slower than the optimum for that weight results in a steeper flight path angle and less range.

In Figure 1, both airplanes could be exactly the same but gliding at different speeds, and the plane on the left could be at a speed faster or slower than the other plane. What's important is that there is only one optimum glide speed for a particular airplane weight, but there is one AOA that ensures the optimum glide speed and maximum range for every airplane weight.

Last month we explained how stall speed depends on airplane weight because the stall AOA doesn't

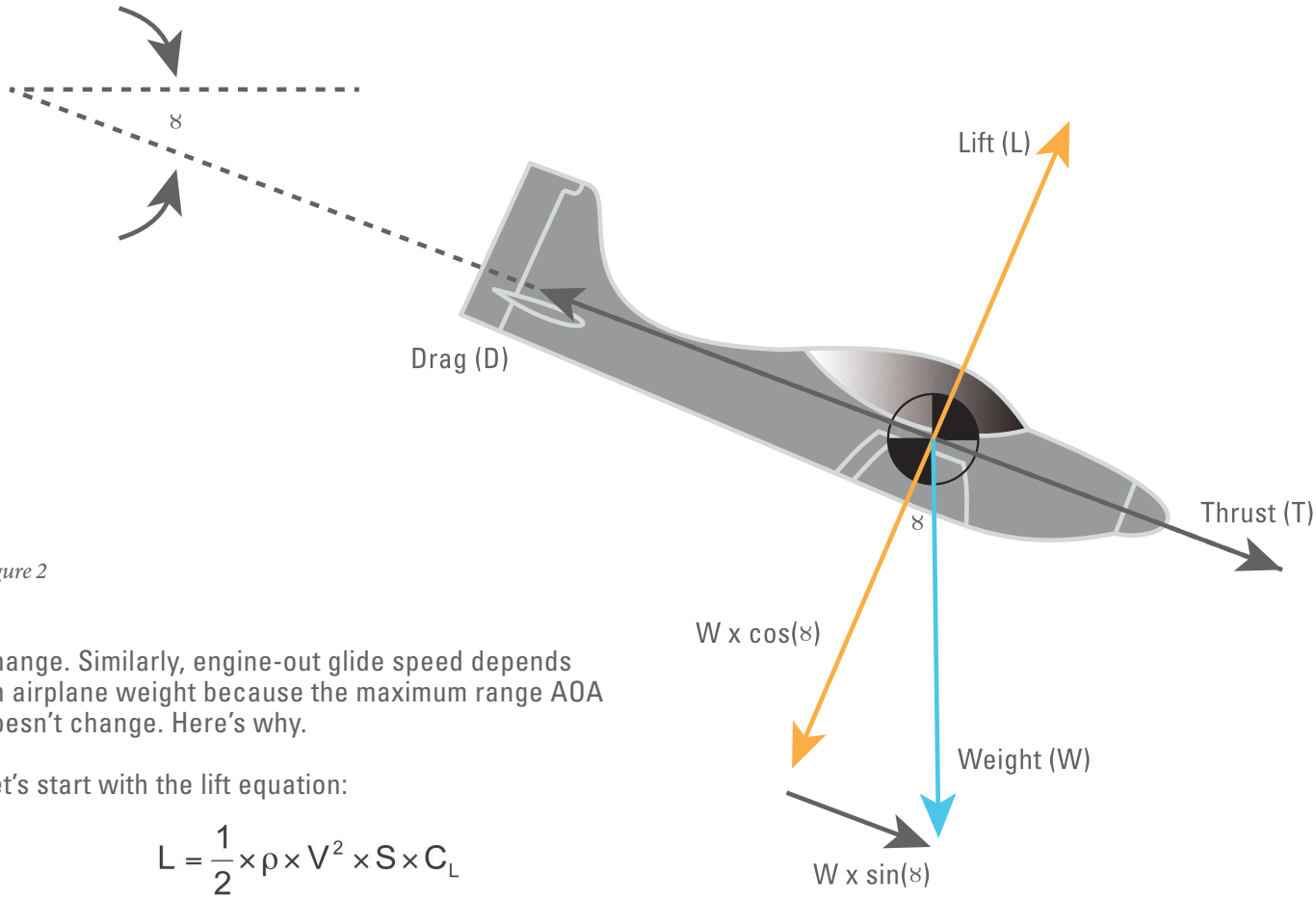


Figure 2

change. Similarly, engine-out glide speed depends on airplane weight because the maximum range AOA doesn't change. Here's why.

Let's start with the lift equation:

$$L = \frac{1}{2} \times \rho \times V^2 \times S \times C_L$$

Where L is lift, ρ(Greek letter rho) is air density. V is true airspeed. S is wing area. C_L is lift coefficient. Recall from last month that C_L is uniquely related to AOA. In other words, there is only one C_L that corresponds to a particular AOA. There is also only one C_L that will provide the maximum lift-to-drag (L/D) ratio, which is the L/D ratio your airplane must be flown to achieve its maximum range.

Max L/D

Figure 2 shows the forces acting on your airplane during a steady descent. Notice that lift is perpendicular to both thrust and drag, but weight points straight down. For easier force comparison, we've shown the weight components acting parallel to lift (W x cos γ) and parallel to thrust and drag (W x sin γ). Cos and sin are the trigonometry functions cosine and sine.

During a steady descent, all the forces are balanced. From Figure 2, you can see that lift equals the weight component perpendicular to the flight path (L = W x cos γ), and drag equals the sum of thrust and the weight component parallel to the flight path (D = T + W x sin γ).

But thrust is zero during an engine-out glide, so D = W x sin g. A little equation manipulation:

$$L = W \times \cos(\gamma) \qquad D = W \times \sin(\gamma)$$

$$\frac{L}{\cos(\gamma)} = W \qquad \frac{D}{\sin(\gamma)} = W$$

We now have two expressions for W, so let's set them equal to each other and do a little more manipulating.

$$\frac{L}{\cos(\gamma)} = \frac{D}{\sin(\gamma)}$$

$$\frac{L}{D} = \frac{\cos(\gamma)}{\sin(\gamma)} = \frac{1}{\tan(\gamma)}$$

L/D equals one over the tangent of the flight path angle. To ensure the maximum L/D, we want the smallest tan (γ) possible, and that means we want the smallest γ

possible. This is our proof that the smallest, or shallowest, flight path angle occurs when L/D is maximized. Notice there's no W in the last equation. That's because your airplane's glide range does not depend on its weight.

Okay, so far we know that the maximum glide range is achieved when your glide has the smallest flight path angle, and that occurs when your plane is flown at its maximum L/D. Now we'll show that the maximum L/D occurs at a single value of AOA.

If we look only at the lift equation, the biggest value of C_L would produce the biggest value of L, which might imply the greatest L/D, but this is not the case. Take a look at the drag equation.

$$D = \frac{1}{2} \times \rho \times V^2 \times S \times C_D$$

Notice the similarity to the lift equation. C_D is the drag coefficient, and it accounts for induced and parasite drag. Figure 3 shows a generic relationship between the lift curve and the drag curve versus AOA. Notice how the increase in C_D dramatically exceeds the increase in C_L at higher values of AOA.

The maximum L/D, which is the same as maximum C_L/C_D, occurs where the vertical distance between the two curves is greatest—well below the AOA for maximum C_L. You can also see that there is only one AOA where this occurs. (For the purists, the lift and drag curves in Figure 3 would normally be vertically separated. They're shown as they are to make the illustration more clear. The maximum C_L/C_D AOA is the same.)

You already know from last month that the lift curve in Figure 3 applies to any airplane weight at any altitude. The same is true for the drag curve. The bottom line here is there is only one AOA that will give you the farthest engine-out glide range, and this is why you can't stretch a glide. Your glide speed and descent rate will be faster when your airplane is heavier, but the range will remain the same.

If you change the airplane's configuration, as in lowering the flaps or leaving the prop in flat pitch, the lift and drag curves in Figure 3 will change, but there will still be just one AOA (probably different from the clean configuration AOA) for each configuration that produces the farthest glide distance.

There's a technical aviation term called the pucker factor. It's a variable whose intensity depends on the nature of the event that causes its occurrence. No one has yet derived a reliable equation for the pucker factor, but empirical data and qualitative evaluations allow us to conclude that a sudden loss of engine power yields an immense pucker factor.

Sizable pucker factors inhibit a pilot's math skills and recollection acumen. What's my best glide speed? What airplane weight does it apply to? How much does my plane weigh right now? What's the speed adjustment I have to make to make sure I'm flying at the best glide speed? Wouldn't it be reassuring to know that little "tic" mark labeled "Max L/D" on your AOA gauge guarantees the best glide?

Following an engine failure, most of us will probably transition to some memorized glide speed as we attend to the other restart and forced landing procedures. This procedure might be sufficient if your selected landing site is nearby or if your restart is successful or if the weight variation of your plane is small enough that a single glide speed guarantees 99 percent maximum range for any weight. For all other conditions, that AOA gauge could be a lifesaver.

An AOA Bonus

Beyond the value of AOA as a stall margin indicator and maximum glide range instrument, there's another benefit. Your airplane will cruise farthest when you fly at its maximum L/D. Your airplane's maximum L/D AOA is the same for maximum cruise range as it is for maximum glide distance, assuming the airplane configuration (landing gear, flaps, etc.) is the same.

Let's take a less technical, more intuitive approach to this. Maximizing range is about efficiency. The more efficiently you fly your airplane, the farther it will travel given its available altitude or fuel. Maximum lift and minimum drag would certainly be ideal, but the laws of aerodynamics don't allow this. Maximum lift occurs just as the wing stalls. Even if you flew a couple of knots faster than stall speed, you wouldn't get very far because of the slow airspeed and high power (and fuel flow) requirements of slow flight.

Minimum drag seems like a good idea, but what you gain in endurance because of the lower power requirement you lose in the resulting slow airspeed. Your fuel would last longer, but you wouldn't travel as far.

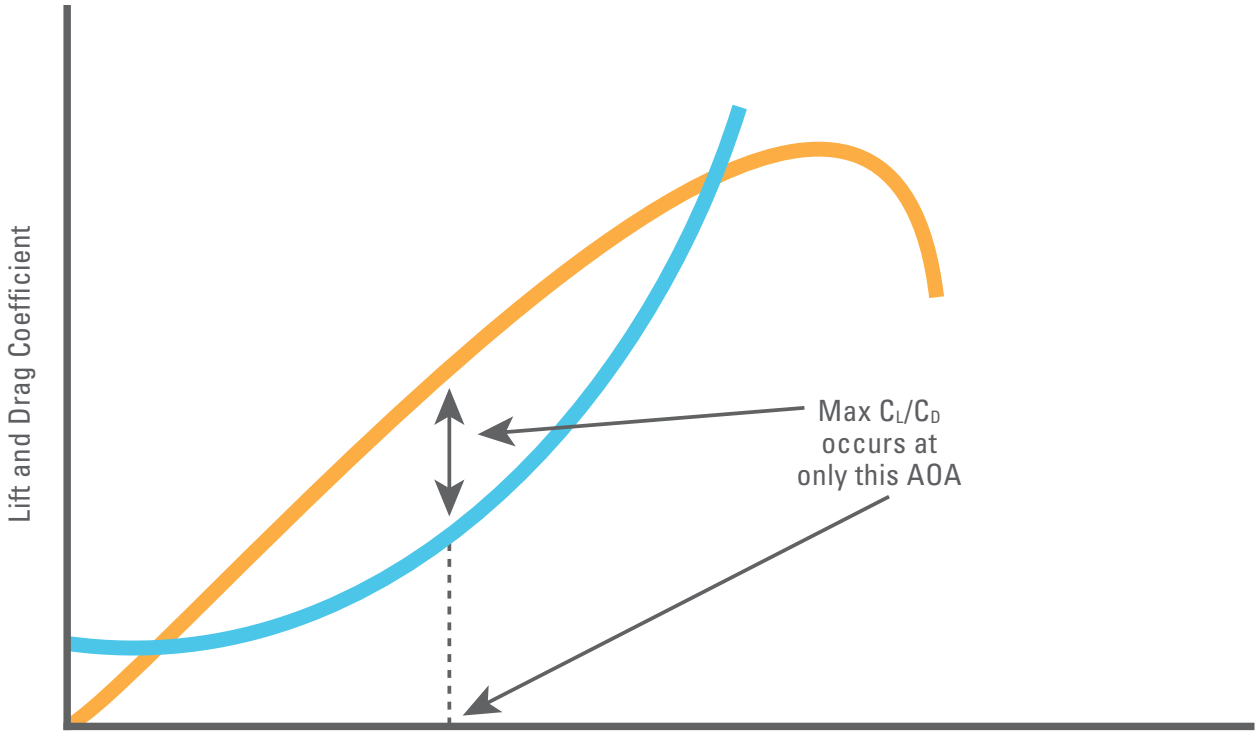


Figure 3

There is some condition between minimum drag and maximum lift where the trade-off between less power and more speed gives you the best deal. This occurs at the maximum L/D, which occurs at only one AOA—the same AOA as your airplane's maximum range glide AOA.

Why does weight affect speed and not AOA? As your airplane burns fuel during a trip, it becomes lighter. If you fly a constant airspeed, you'd fly at a progressively lower AOA as fuel burned and your cruise range would be less. If you continue to fly at your maximum range AOA, you'd have to fly progressively slower as fuel burned, but you would get the most mileage from your fuel.

Whether maximum efficiency is important depends on your needs. Most pilots cruise at a faster speed, and lower AOA, than maximum range AOA. These pilots trade money (for the extra fuel speed costs) for a shorter flight (the result of speed).

Someday, however, you may face a diversion because of weather or an unexpectedly closed airport, and you may not have enough fuel to reach your new destination using your normal cruise speed. Having the ability to reference your "Max L/D" mark on your AOA gauge could just give you those needed extra miles.

If AOA is so wonderful, why doesn't the FAA require AOA indicators in airplanes? Good question. Pilots can be just as safe and efficient with proper flight planning, solid piloting, understanding their airplane, and good judgment without an AOA gauge. Having AOA at their disposal makes it easier.

For some small airplanes whose weight doesn't vary much, a few airspeed references for maximum cruise and glide range and 1*g* stall may be sufficient. For many amateur-built airplanes, however, where fuel and payload weight can vary by a substantial percentage of the airplane's overall weight, there can be a considerable consequence in range penalties and stall margins.

Next month's topic will be flight path stability. It's called stability, but it's really about how changing your airspeed during final approach affects your glide path—and it's different for different airplanes. EAA

Ed Kolano, EAA 336809, is a former Marine who's been flying since 1975 and testing airplanes since 1985. He considers himself extremely fortunate to have performed flight tests in a variety of airplanes ranging from ultralights to 787s.

Lead Museum Store Representative Kyle Voltz checks a cleco for proper seating.

New Tricks

Three things you should know if you want to teach someone like me to build an airplane

By Hal Bryan

I've been learning a lot lately about building airplanes. I've been building every week on the EAA staff's Zenith CH 750, and I've attended a couple of EAA SportAir Workshops. But in addition to learning about building, I've also learned a thing or two about how I learn.

There's not much I can teach readers of *Experimenter* about building airplanes, at least not yet. But that's not really the goal of my column. The goal, or one of them, is to share my experiences as I slowly work toward the hat trick of EAA membership: I've been a pilot for what seems like all of my life, an enthusiast for longer than that, and now I'm working glacially toward adding craftsman to the list. In the process, I hope I can teach you a few things about how you, the real builders, can help someone like me get started on his own project.

Here are three bits of common sense I've found to be extremely helpful as I've started learning construction techniques, both in the classroom and hands-on with our own project.

Start Simple

Like most people, I don't like being involved in a conversation where I have no idea what the other person is talking about. Thanks to my age and my status as a self-proclaimed super genius, this doesn't happen very often, but when it does, it's extremely uncomfortable.

Photography by Jason Toney

So, when it's time to teach someone like me about something new, the first rule is to start simple. Establish some common ground or an anchor, if you prefer, by opening with the basics, even if it's something you're pretty sure I already know.

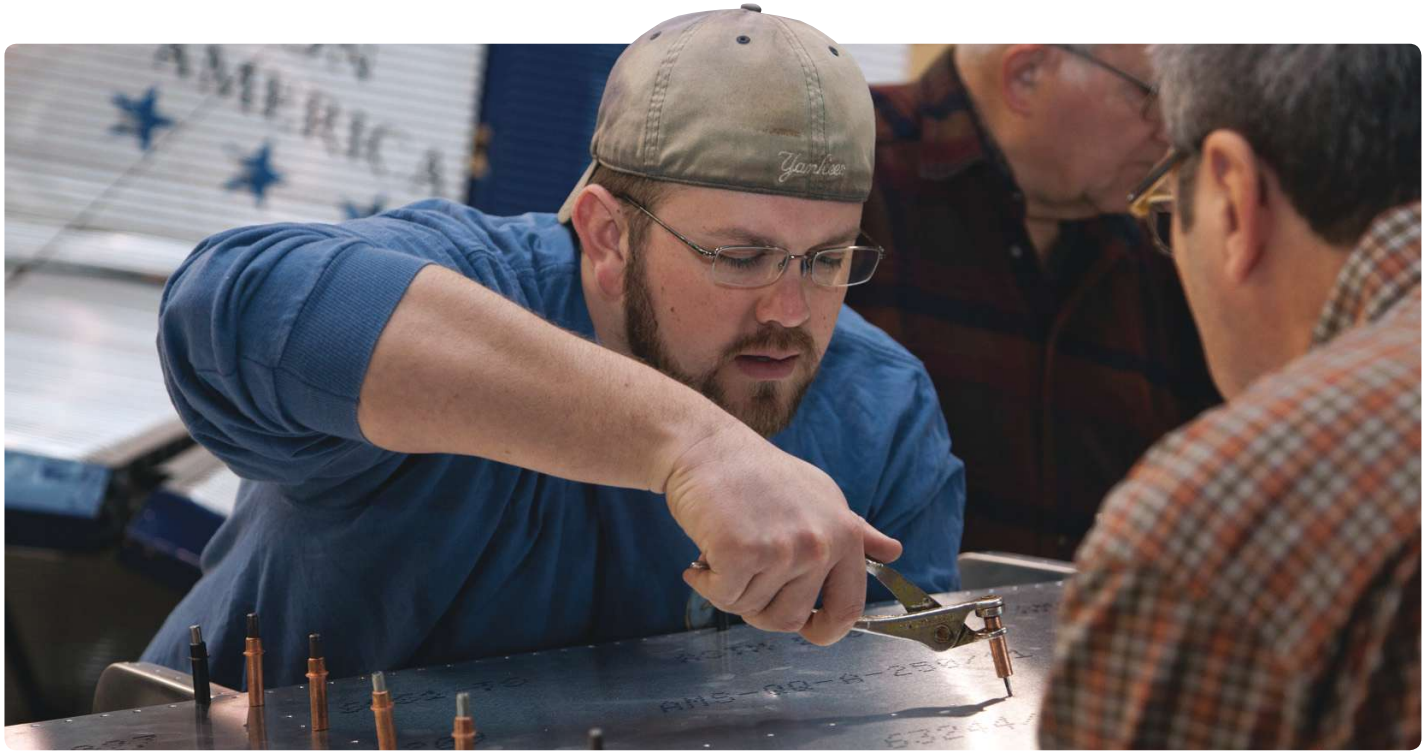
If you want to teach me how to rivet, for example, start by making sure that I know how rivets work. Take two minutes to explain how they pass through holes in two pieces of metal and then are compressed and flattened. Pulling a pop rivet by hand and watching the "other" side of it is a great way to do this. There will be time to explain things like the intricacies of AN hardware numbering soon enough, but be sure you start with at least a quick look at the basics. If I start from a comfortable position, I'm off and running and ready to learn. If I'm lost a moment after you open your mouth, it's not going to go well. To be terribly blunt, I'd rather be treated like an idiot (briefly and within reason) than made to feel like one.

Government Advocacy Specialist Jonathan Harger (with Jim Casper and Jerry Paveglio) inserts a cleco.

Tell Me Why

I'm not necessarily proud to admit that, on our Zenith project, I've often let someone else read the plans and then point me at a series of holes to be drilled or rivets to be pulled, and then I've just run on autopilot from there. Given the number of repetitive tasks on a build like this, that's not immediately a bad thing, but if you were to interrupt me and ask me about what the next step in the instructions were, what part I'd be working on next, or even why this particular step was necessary, I might not know the answer. If I didn't, it would be because I lacked context. While this can be okay at times, especially in a team build like ours, it would be a recipe for failure if I were building on my own. If I let myself spend too much time in that sort of "passive automation" mode, it would be all too easy to make mistakes—drilling one too many holes, putting a rivet where I was supposed to just put a cleco—because, in effect, my brain has been turned off.

When I was in high school, I had a precalculus teacher named Mr. Tubbs. Looking back more than 25 years later, I'm not even sure what calculus actually is, but there is one lesson he taught that I'll never forget. Whenever someone would get impatient with the time we spent on theory and wanted to just start working on the math problems, he'd adopt this high, whiny voice and say mockingly, "Oh, show me number one, Mr. Tubbs. I can do the rest!" The first few times I heard this, my responses were "Man, that's irritating!" and "Yes, exactly!" But over time I started to get what he meant. If I only learned how to solve one specific type of problem with no understanding of the theory behind it, then while I could certainly complete



Multimedia Specialist Brady Lane shows Events Manager John Dorgan how to insert a cleco. Brady and Caleb Ihrig are also scratchbuilding a tube-and-fabric Bearhawk. You can follow their progress here.

that day's assignment, I'd have absolutely no idea what to do when an even slightly different problem came along.

There are lots of "whys" in homebuilding. Why do I keep painting this stuff on the fabric? Why did I put these things together only to take them apart again? These holes are already drilled; why do I have to drill them again? I can coat fabric, assemble and disassemble parts, and drill holes whether or not I know why I'm doing it. However, when I can keep one eye on the big picture and really understand what I'm doing and why, then my work is of much higher quality and I enjoy it that much more. In effect, it's the difference between using a tool and being one.

Remind Me About Resources

I recently took Jim and Dondi Miller's excellent SportAir Workshop on fabric covering. Two things that really struck me about the class were Jim's encyclopedic knowledge of aircraft types and his frequent reminders to use him as a resource after the class. He had some bit of very specific advice for everyone in the room, rattling off things like "Oh, you're building a Tubman 601? Okay, when you're covering the turtle deck, call me because there's a little flange between the 16th and 17th longeron that makes kind of a 'w' shape; and I've got a neat trick I can talk you through…" In this case, Jim is just offering customer support, impressive as it is, but the message is simple: You're not alone! When I was attending this workshop, there was a small fear nagging at the back of my mind: How much of this was I going to remember when the time came that I needed it? That's when a promise like Jim's becomes invaluable. That simple suggestion to give him a call erased that fear fully and completely. Not necessarily because of the specific offer to help, though that's valuable on its own, but because it was a reminder that help is available, period.

Whether that help comes from a vendor or a friend or a (temporary) stranger at your local EAA chapter, it's out there. As an EAA member, you also have technical counselors at your service, volunteer experts who will visit your project, answer questions, and offer advice and encouragement. And this being the 21st century, there are all kinds of resources available online, from archived EAA publications to Hints for Homebuilders videos, not to mention the active discussion boards at EAA Forums.

So, if you want someone like me to learn how to build an airplane, just start simple, explain the context, and make sure he knows that help is always available. Show me those three things, and I can do the rest. EAA

Hal Bryan is EAA's social media manager and a first-time airplane builder.

Photography by Jason Toney

CubCrafters recommends its custom 340 engine made up of mostly ECi parts for its Carbon Cub. Although this engine includes many parts that are only available through CubCrafters, the basic O-340 "stroker" engine is available from any ECi engine builder.

Picking an Engine for Your Project

How experimental do you want to be?

By Dave Prizio

You've started building an airplane, so what engine are you going to use? There are usually a number of choices, so how do you decide which one is best for you? A plan of attack to evaluate the pros and cons of each possible choice seems in order. Here are some things to consider:

- the designer's recommendation
- engine weight and power
- service history of maintenance and reliability
- the availability of support from manufacturers and other vendors.

Let's look at each factor.

The designer of any airplane (plans-built or kit) starts out with an engine in mind. That should be the basis of any decision you make because the weight and power of that recommended engine are likely to work the best in installation if the original design was based on them. Some other manufacturers may have engines of similar weight and performance, as in the case of Superior and ECi making engines nearly identical to Lycomings. Switching between these brands is usually pretty painless, but it's a good idea to pay close attention to the little details such as intake

configuration and accessory and governor mounting pad locations. Even within the model designation of Lycoming O-360 there are some five dozen different configurations. Refer to Lycoming's publication SSP-108 for details on the different engine models they have.

The same manufacturer may have engines that are similar but more or less powerful, such as the Lycoming O-320 and O-360 engines. With an added weight of 20 pounds or so, an extra 20 hp can be gained. But sometimes the weight gain is much greater, making the trade-off less beneficial. This is the case with the difference between the Lycoming IO-360 parallel valve engine and the more powerful but much heavier IO-360 angle valve engine.

Everyone wants more power, but the urge to gain power at the expense of significant added weight and increased physical dimensions often leads to problems. Although less weight is usually easier to deal with than more, a switch from an engine such as the Continental O-200 to the much lighter Rotax 912 ULS can cause center of gravity problems that could be difficult to overcome. The further you deviate from the original design weight and power, the more difficult you will make things for yourself.

Auto conversions can make this process even more complicated because accurate weight and power numbers are often difficult to come by. It can be a most unpleasant surprise to find out after your airplane is finished that your engine makes less power and/or weighs more than you expected. Good advice for all aircraft builders in general and engine selection in particular is to avoid adding weight and complexity whenever possible.

If the first two sins that airplane engines can commit are not making enough power and weighing too much, the very next is not being reliable. In fact, unreliability should probably be moved into first place. After all, poor performance will disappoint you, but unreliability can kill you. The engines that have met the test of long-term reliability and serviceability are made by one of three manufacturers: TCM (Continental), Lycoming, and now Rotax, with Superior and ECi included as Lycoming clones. To be sure, all of these companies have had their problems, but they have withstood the test of time by refining their products and taking care of their problems such that they now produce the most reliable aircraft engines currently available. It does not mean that all other

Everyone wants more power, but the urge to gain power at the expense of significant added weight and increased physical dimensions often leads to problems.

Your author torques the head bolts on his Jabiru 3300A engine during an annual inspection. This engine saves about 30 pounds compared to a Continental O-200, but it was more difficult to get running well and requires more maintenance.

Photography by Dave Prizio and courtesy CubCrafters

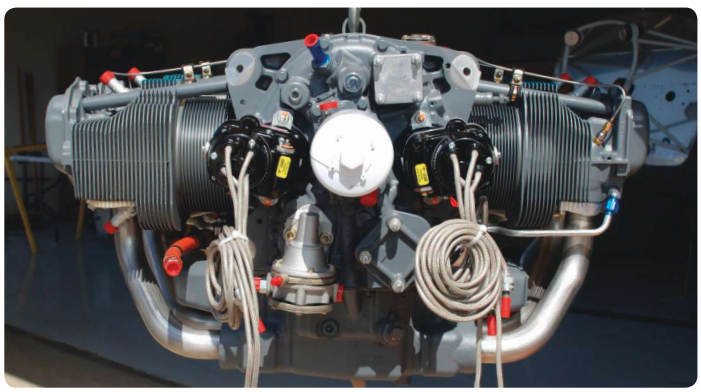
An EAA member checks out a Subaru auto engine conversion at EAA AirVenture Oshkosh. Sadly these engines did not live up to their expectations. The supplier of this engine is now out of business.

engines are bad, but it does mean that those engines are less likely to give you years of reliable service. How much less varies from a little to a lot, depending on the engine. Or at the very least, it means that other engines have less of a history of reliable service to support such a claim.

Some alternative engines that are purpose-built for airplanes but do not yet have the track record of the big three include: Jabiru, Rotec, and ULPower. All of these engines have their admirers, but the track record is not yet there to place them in the same category of reliability and serviceability as the majors. Any one of them may be a reasonable choice for your project, but expect to solve more problems yourself with fewer outside resources than would normally be available for the major brands.

Along with reliability and serviceability comes the consideration of support from the engine manufacturer. You can get Lycoming and TCM parts everywhere. Their respective factories offer technical support, and there are other people available who have strong expertise in dealing with these engines. This is less true of Rotax, but that is improving as more and more light-sport aircraft are equipped with Rotax engines.

Parts and technical assistance for less common engines are, as you would expect, less readily available. Some parts



This factory-new Lycoming IO-360 engine is set to be installed in an RV-8 project. This is an ideal engine for that particular airplane.

for auto conversion engines are easy to find, but others may only be available from one small manufacturer. For example, more than one Subaru engine conversion has been left orphaned by the manufacturer going out of business.

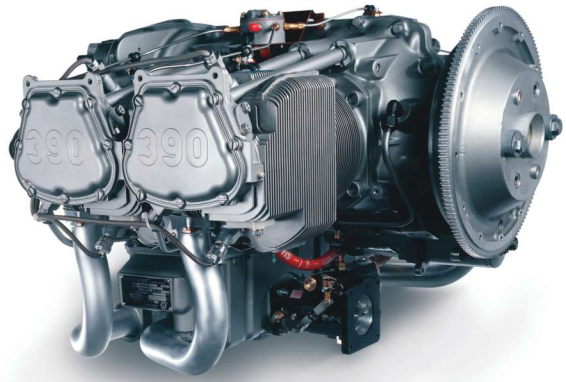
Auto engine conversions deserve their own look because as a group they are involved in a disproportionately large number of experimental airplane engine failures. In spite of this fact, auto conversion engines attract many builders with promises of better performance and lower cost. Some engines in this group, such as the AeroVee, have a very good track record and are backed up by a

substantial airframe kit manufacturer (Sonex). Some Corvair engine conversions also have performed well, while others have not. Subaru engine conversions have been particularly troublesome for most builders, and not because the engines themselves are defective. It is just much more difficult to make an auto engine work in an airplane than most people imagine. Propeller speed reduction unit, cooling, and ignition problems have been particularly common with these engines. Does this mean that you should never buy an auto conversion engine for your plane? No, but you surely need to do so with your eyes wide open and after talking to a number of builders who have been down that road before you.

The best airplane engines for your experimental amateur-built project fall well within the aircraft designers' basic engine guidelines; they are simple and reliable, and they are easy to maintain and install with good support from the manufacturer. But you, as an experimental builder, can pursue your dreams wherever they may take you. Just remember, the further afield you go with your engine choice, the more of an experimenter you become. Weigh your choice carefully, and be conservative and methodical in your building and test flying.

A wise man once said, "There are hazardous ways of doing safe things, and there are safe ways of doing hazardous things." Experimenting with airplane engines usually falls into the category of hazardous things. If this is your calling, please do your best to stay safe as you do it. We like having you around. EAA

Dave Prizio has built three airplanes and is working on a fourth. He is a regular contributor to *Kitplanes* magazine and is a member of the EAA Homebuilt Aircraft Council.



The Lycoming IO-390 engine is an ideal engine for a Glasair Sportsman or the new Van's RV-14, but it is considerably heavier than the parallel valve IO-360. This makes it less than ideal for use in a plane like an RV-8, which was designed to use a lighter engine.

Sonex has put the AeroVee VW engine conversion to good use in many of its fine, affordable airplanes.

Photography by Dave Prizio and courtesy Lycoming

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