EAA EXPERIMENTER

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Vol.2 No.4 | April 2013

A FALCO from New Zealand

George Richard's masterpiece

A Turbine CH 701
Is it practical?

Buying a Used Rotax Engine
What you need to know

The Type Club Coalition…

…and you

By Rick Weiss, Chairman, EAA Homebuilt Aircraft Council

The Type Club Coalition (TCC) is an entity you should get to know more about because it could be the resource you need to learn more about your type of aircraft. This is especially true for all of you orphan aircraft owners—that is, owners of plans/kit-built aircraft that are no longer supported by the original designer/manufacturer.

The formation of type clubs happens primarily to promote safety, but there are numerous other benefits associated with like type owners getting together, such as operational standardization, maintenance issues, design improvements, etc. Recent *EAA Sport Aviation* articles have emphasized the importance and advantages of forming a type club. Since the recent issuance of the National Transportation Safety Board's (NTSB) report, "The Safety of Experimental Amateur-Built Aircraft," your EAA Homebuilt Aircraft Council has been reviewing the types of orphan homebuilt aircraft and have found that, although like owners network with one another and share information, there is very little documentation that helps promote safety. A formal type club could provide the following help for the individual types:

- standard pilot's operating handbook (POH), though we recognize that the numbers will be somewhat different due to individual configurations, weights, etc.
- aircraft information manual—useful information not contained in the POH, such as background information, questionnaire, building/flying tips, accident reports, etc.
- parts pool—very important with limited kits, offering the potential to reduce costs
- scheduled fly-ins/membership meetings
- periodic newsletters
- published membership list
- primary point of contact for EAA Headquarters to disseminate information
- Members who have a letter of deviation authorization (LODA) can provide formal checkouts and proficiency checks in experimental amateur-built (E-AB) aircraft of the same type or similar. Learn more here.

Any EAA members who build an aircraft and use the expertise of a technical counselor and flight advisor, and subsequently maintain proficiency in their aircraft while properly maintaining it, can expect to have many hours of accident-free flying comparable to or better than the overall general aviation (GA) safety record. However, as the NTSB report points out, E-AB aircraft represent nearly 10 percent of the U.S. GA fleet, but account for approximately 15 percent of the total accidents and 21 percent of the fatal U.S. GA accidents. We must take steps to reduce these numbers if we expect to continue to exercise our freedoms of building and flying E-AB aircraft.

Remember, this freedom is not in the Constitution or Bill of Rights. It's a privilege granted to us by our government. If the accident numbers don't show improvement, the FAA could restrict our activities, add additional rules and requirements, or take away this precious right. It's our responsibility as builders and pilots to not let this happen.

As the preeminent expert in this area of aviation, EAA remains in the forefront of these issues and continually educates and helps the FAA to understand how we, as builders and pilots, can safely go about our business of enjoying our sport. For specific information on how to form your own type club, call EAA's TCC coordinator, Tom Charpentier of the EAA Advocacy and Safety Department, at 920-426-6522. Do it now. Then go dream it, build it, and fly it—*safely*! EAA

On the cover: George Richards flies his Falco in his native New Zealand. (Photography by Darryn Morgan)

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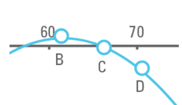

The Wright Flyer B Accident

I mentioned this to Chad [Jensen] in a phone conversation, [but] even with flawless welds I suspect the prop shaft design [of the Wright Flyer Model B] may have been lacking in the failure area considering the engine horsepower, two chain drives, relatively large prop diameters, substantial associated rotating mass with the possibility of opposing resonant frequencies, or just inadequate even for synchronous engine/chain drive/prop frequencies. I am not a professional mechanical engineer, just an old A&P/IA lifetime shop guy. I would love to hear an engineer's take on this, if you come across one.

Hopefully, if my comment proves out, it would be passed along to members in print, for their consideration in similar applications.

Steven L. Dawson
EAA 60588

Steve…we're printing your letter in case some engineers want to weigh in on your observation. .. Ed.

Love Experimenter!

Love the digital *EAA Experimenter*! Crisp text and vivid photos, and I can read it anywhere and keep it for future reference. I [download a PDF] typically to read it on my iPad mini because I can open it anywhere, unlike carrying a magazine with me. The photos really pop on the retina display. I estimate I read about 80 percent of each issue.

Bern Heimos
EAA 538444

Thanks for the kind comments, Bern. Glad you're enjoying the digital issue. – Editor

How do you read the digital *Experimenter*? We'd like to know your viewing habits. Do you read it online, or do you download a PDF to your computer or tablet and come back to it multiple times over the month? Do you find the articles too long? What's your favorite column? Is there a different subject area that we should cover? Write and let us know. Please direct your comments to experimenter@eaa.org.

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NTSB Announces GA Safety Alerts

The National Transportation Safety Board (NTSB) voted unanimously in March to adopt five new safety alerts aimed at reducing the number of general aviation (GA) accidents, which have been on a decade-long plateau. Safety alerts, or brief information sheets pinpointing safety issues and practical remedies to address them, would focus on the main accident causes determined by the NTSB's investigative data, which are:

1. reduced-visual-reference accidents, including controlled flight into terrain and uncontrolled descent to the ground due to spatial disorientation
2. aerodynamic stalls at low altitude in daylight visual weather conditions
3. pilot inattention to indications of mechanical problems
4. risk management for aviation maintenance technicians
5. risk management for pilots.

NTSB Chairman Deborah Hersman said that over the past decade, "the GA accident rate has plateaued, with repeated crashes and needless loss of life. Today we meet to discuss what we, the NTSB, can do to bring the accident rate down."

It was stressed that the new alerts are neither a package of safety recommendations nor regulatory changes/rulemaking. Rather, they're a new technique to try to get the latest word on safety directly to GA pilots and mechanics and provide them with information to incorporate into their flight preparations so they might be more able to handle crisis situations should they arise.

The NTSB is also creating five short (3- to 5-minute) videos—one for each alert—it plans to roll out in the spring. The videos will feature regional air safety investigators sharing their experiences and observations of the many accident investigations they've conducted, as well as advice on how pilots and mechanics can avoid mistakes that can result in tragic consequences.

"GA is essentially an airline or maintenance operation of one, which puts the responsibility for sound decision making on one person's shoulders," Hersman said. "We are promoting and distributing the alerts to reach pilots and mechanics who can benefit from these lifesaving messages."

Outreach efforts will include type clubs, GA organizations, major events such as EAA AirVenture Oshkosh and Sun 'n Fun, and other methods.

Helicopters Have a New Home at AirVenture

The Helicopter Association International (HAI) and EAA have made a joint commitment to give helicopters a new prominence at EAA AirVenture Oshkosh.

The two organizations inked a three-year deal to keep HAI's Heli-Center located near the AirVenture flightline, not far from Phillips 66 Plaza. As part of the deal, the area between the HAI Heli-Center and the flightline will be designated a helicopter display and parking area, putting certificated rotary-wing aircraft at show center for the first time ever.

The huge 80-foot-by-120-foot HAI Heli-Center will be the place to learn more about helicopters during AirVenture. HAI staff will be on hand to answer questions about the industry, as will HAI member companies that can talk about learning to fly helicopters. Meet with industry experts, and learn what it's like to work in such a diverse industry.

In addition to the Heli-Center, AirVenture is exploring ways to integrate helicopters into its famous daily air shows. Red Bull aerobatic helicopter pilot Chuck Aaron has wowed the Oshkosh crowd with his skills over the past several years. This year, EAA will be looking for additional ways to showcase the incredible array of things helicopters can do.

HAI members interested in participating in the HAI Heli-Center or who just want to park or display their aircraft in the dedicated helicopter location front and center on the flightline should contact HAI's Lisa Henderson at lisa.henderson@rotor.com.

EAA Air Academy Among MSN's 10 Summer Camps Worth the Money

EAA Air Academy summer camp programs have been recognized by MSN Money as one of 10 nationwide summer camps that are "worth the money," the website announced this week. Camps were chosen for not only keeping young people busy during the summer but giving them a chance to develop passions and expand their horizons.

Since 1984, the Air Academy's weeklong series of camps have been designed to immerse young people ages 12 to 18 in the world of aviation. Campers are engaged through a variety of hands-on activities while staying at the EAA Air Academy Lodge in Oshkosh. Experienced aviation instructors help them delve into flight through studies, hands-on demonstrations, flight simulation, and other exciting activities.

"Kids will explore aviation through technical and learning classrooms, as well as hands-on experiences that give them life skills," said Bob Campbell, EAA director of museum and museum education. "The camps are a week of nonstop excitement where fun and discovery combine for an experience that young people can find nowhere else."

Twelve- to 13-year-olds are introduced to flight in the EAA Young Eagles Camp through small group activities taught by expert camp counselors. The EAA Basic Air Academy takes things to the next level, incorporating more hands-on projects and demonstrations for kids ages 14 to 15.

Introductory recreational flight experiences highlight the action-packed EAA Advanced Air Academy Camp for 16- to 18-year-olds and give students full access to EAA AirVenture Oshkosh action throughout the week. Sessions for 2013 are currently full; any additional applicants will be added to a waiting list and notified on a first-come, first-served basis if a spot opens.

A new camp added this summer is the EAA Advanced Air Academy/SportAir, for kids ages 16 to 19. This camp places a strong emphasis on aircraft construction, primarily composite and fabric techniques.

Air Academy enrollment is available on a first-come, first-served basis, and positions fill up quickly. For more information and to apply for a 2013 Air Academy camp program, visit www.YoungEagles.org/programs/airacademy.

ELT Issue Heats Up – Again

The Federal Communications Commission (FCC), at the urging of federal agencies with aeronautical search and rescue (SAR) responsibility, has proposed to prohibit the manufacture and sale of new 121.5-megahertz emergency locator transmitters (ELTs).

These older ELTs have not been monitored by the SAR satellite system since 2009. For 20 years the SAR community has been pressing for a mandated change to 406-megahertz ELTs, a move that has been staunchly opposed by EAA and other aviation organizations. Even the FAA has been on record as recently as last year as not supporting such a mandate.

In a meeting at the end of February between FCC personnel and GA representative organizations, it was made clear that not only did the FCC intend to ban the future manufacture and sale of new 121.5-megahertz ELTs, but that it was also contemplating an outright ban on the use of the older technology ELTs in the final rule, despite no mention of this in the proposal.

The comment period was originally due to close on March 1, 2013, but EAA and several other associations petitioned for an extension, citing the need for more time to evaluate the impact of the proposal, particularly in light of the possibility of an outright ban on the use of 121.5-megahertz ELTs.

The new comment period deadline was April 1. EAA and the GA community remain united in opposition to a mandated transition from 121.5-megahertz to 406-megahertz ELTs and are working to oppose this sweeping and veiled proposal. At the same time, EAA strongly encourages its members, when confronted with the need to repair or replace a 121.5-megahertz ELT, to do so with modern 406-megahertz or multiband ELTs that are being actively monitored by SAR. EAA will keep members updated on future rulings.

Sam LS Makes First Flight

The Sam LS made its first flight on February 26 in Montreal, Quebec, Canada. The highly anticipated flight took place at Lachute Airport near Montreal.

"Liftoff was perfect, in about 300 feet," said Thierry Zibi, president of Sam Aircraft. "We were not at gross weight, so our climb of nearly 1,300 feet per minute felt like a rocket."

Test pilot Raphaël Langumier reported that the initial handling was exactly as expected. "With the prop set at a climb setting, we saw a maximum level speed of 127 mph," he said.

The 21-minute flight covered the basics: 30-degree banks, straight flight, and gentle control. "There is a lot more to test," Zibi said, "but all indications are that the aerodynamics are exactly what we have expected all along."

The Sam LS is a roomy tandem, retro-look metal aircraft, powered by the 100-hp Rotax 912S and sporting a Sensenich ground-adjustable composite propeller. It's available ready-to-fly or as a kit in three configurations (short, long, and standard wing). As an (available) 250-hour quick-build kit, the Sam LS was designed to have the distinctive classic look of a warbird trainer. Sam Aircraft calls it comfortable, rugged, easy to repair, economical, and fun.

Deliveries of the first kits are scheduled for late summer 2013. Deposits for delivery positions are open; the introductory ready-to-fly price (FOB Canada) is $135,000 and includes some attractive upgrades at no charge. The standard kit is priced at $39,000.

For a video of the first flight, visit www.EAA.org/news/2013/2013-03-06_SAM-LS-makes-first-flight.asp.

Rotax Releases Alert Service Bulletin

Rotax has released ASB-912-062 / 914-044 R1. This mandatory alert service bulletin covers the inspection of cylinder heads No. 2 and No. 3 for oil leakages into the intake port on Rotax 912 and 914 series aircraft engines.

Download the service bulletin and view the video. This video will help you determine whether your engine is affected and will describe the simple process of checking an affected engine.

Florida Sonex Association to Hold Zephyrhills Fly-In during Sun 'n Fun

The Florida Sonex Association will be holding its first annual Spring Sonex Fest fly-in on Saturday, April 13, 2013, at the Zephyrhills Municipal Airport in Zephyrhills, Florida. The event will be held from 10 a.m. to 5 p.m. and is a great opportunity for Sun 'n Fun attendees interested in Sonex Aircraft to experience a grassroots Sonex builder event. The Zephyrhills airport is only a 35-minute drive from Lakeland. Fly-in or transient air traffic is also welcome; however, event organizers and airport management ask that all attendees, driving or flying in RSVP for the event, to make sure adequate food, refreshments, shade, and aircraft parking are available. Learn more at www.FloridaSonex.com.

Sonex Aircraft will also be hosting forums at Sun 'n Fun on Thursday, April 11, and Friday, April 12. Sonex will not have an exhibitor booth.

AeroLEDs Introduces the SunSpot 46 Landing/ Recognition Light

AeroLEDs has developed a larger, more powerful light that can be used for landing, recognition, and taxi purposes. Though it only consumes 70 watts maximum in power, the SunSpot produces 4,000 lumens. The legacy lights it replaces, such as the GE4553 that draws 250 watts, develop 3,750 lumens when new.

The larger SunSpots are available in two models, the 46 HX and 46 LX. Both lights have screw terminals that can be connected in either polarity for steady on light, and the HX has three additional wires that support a built-in pulse mode that can be set up for individual pulsing or synchronized with other lights for wig-wag. The weight of the SunSpot 46—11 ounces—and dimensions—5.6 inches wide by 1.7 inches deep—are no greater than the legacy lights they replace. As with all AeroLEDs, SunSpots have a rated life of 50,000 hours and will withstand temperatures of -55°C to +70°C. Both versions of the SunSpot can operate on 14 VDC or 28 VDC systems.

The SunSpot 46 LX sells for $650, and the 46 HX is priced at $750. At this time, they can be installed in experimental amateur-built aircraft, special-use aircraft, and light-sport aircraft. A PMA for certificated aircraft is expected this summer. For further information, visit www.AeroLEDs.com.

Glasair Rolls Out 160th Aircraft in 'Two Weeks to Taxi' Program

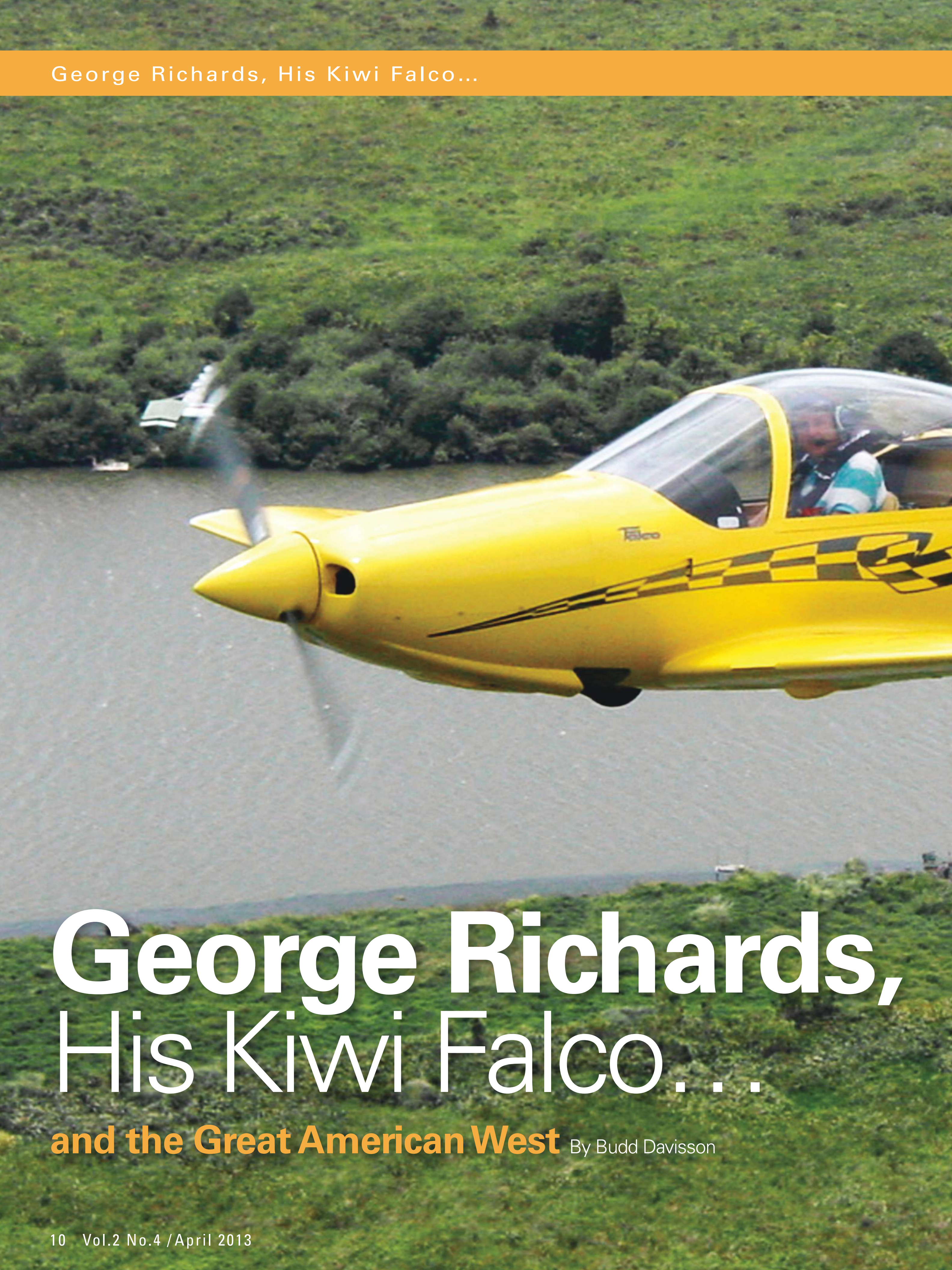
Since the program was started in 2006, Glasair's popular builder assist program has succeeded in bringing 160 Sportsman aircraft to completion. The first 34 kits were able to taxi in three weeks, after which the program was streamlined and renamed "Two Weeks to Taxi."

The 160th aircraft to be completed in the program was built by Rick and Laura Walker of Laredo, Texas. The husband-and-wife team "thoroughly enjoyed the construction process and learned a tremendous amount about what goes into an aircraft and how it functions," according to Rick. He also admitted that they were both "astonished by how much they could accomplish in a day's time with help and direction provided by the Glasair team."

The Walkers are active in ranching and plan to use their Sportsman for surveillance work and trips to cities around Texas.

Glasair's Two Weeks to Taxi program has been thoroughly reviewed by the FAA and approved as meeting all of the requirements for an experimental amateur-built aircraft.

The Sportsman is a four-place, high-wing, metal and composite aircraft that can be configured for taildragger or nosewheel, straight or amphibious floats, or skis. It can be built with a variety of powerplants. Designed for comfort and long-range cruising, the Sportsman is capable of a wide range of mission profiles. For more information, visit www.GlasairAviation.com.



George Richards, His Kiwi Falco...

and the Great American West

By Budd Davisson

When you're walking down the rows of aircraft at any airport, but especially Wittman Field in Oshkosh, Wisconsin, during "that" week, your eyes become accustomed to at least one form of "sameness." From one airplane to the next, one factor is almost always the same—most of the registration numbers start with an "N." Only the occasional "C" from north of the border breaks the pattern. So, when "ZK" was brazenly painted against a yellow fuselage, it really stood out and virtually everyone said, "Huh? What does ZK stand for?"

It was the rare individual at EAA AirVenture Oshkosh 2013 who didn't have to read the prop card to find out that ZK indicates a New Zealand registration. A Falco from New Zealand, to be exact. When that realization soaked in and we each visualized a globe and New Zealand's position on it, we knew we were looking at an airplane that was rooted deeply in determination.

The very fact that it's a scratchbuilt Falco means the builder, George Richards, EAA 474298, from Auckland, New Zealand, is incredibly determined, or he wouldn't have finished the airplane in the first place. And then the simple fact that it was sitting just north of Homebuilders Headquarters in the grass with flightline

Photography by Darryn Morgan

fanatics milling around it means he has pegged the determination meter. It's at that point that you have to give the man even more respect knowing that he's tackled, and whipped, a ton of impossible obstacles.

To answer the first question most people ask about George and his Falco: No, he didn't fly it to Oshkosh, a distance of 8,312 miles, most of it over water.

He said, "I fly A320s for a living, and I think even a 320 would be too small to take to America from home, much less the Falco. I shipped it, and I like to think of the disassembly/reassembly process as something of a home-builder's approach to transporting an aircraft. We use our imagination and ability to solve problems, so I modified a few things on the Falco to make it be a quicker assembly/disassembly process, and despite the shipping company hassles I had, I really enjoyed the rest of the assembly/disassembly process and the people whom I met along the way as a result of it.

"Just so you know, the fuselage comes apart just behind the cockpit section. So, I removed the engine and the rear fuselage half and stood the wing and main fuselage on the firewall on a dolly I constructed. Then the rear fuselage and fully assembled tail and the engine went on a second dolly. This all fit into a 40-foot, on-deck shipping container. But it just barely fit: There was only 5 millimeters to spare at the top of the door."

George didn't build the Falco with the idea of bringing it to Oshkosh. In fact, the reason he built the Falco was…well…because he wanted to build it.

He said, "I started flying in 1979, mostly because it was something I'd wanted to do since I got my first ride in an airplane as a 4-year-old, when visiting England. I didn't actually learn about homebuilt airplanes until much later, in 1992, after I'd already started flying for the airlines. I was waiting for my wife and went into a bookstore to pass the time. I started thumbing through a copy of *Kitplanes* magazine. I've always liked doing things with my hands, and building an airplane seemed like a good thing to do. There was a photo of a Falco, and I really liked the way it looked; so just like that, without doing any research, I decided to build one."

What little research George did do revealed that there were plans for the airplane available, as were many kit components. However, he decided to go the plans-only route.

"I had no experience building anything like an airplane," he said, "but no one told me I couldn't do it. So I started ordering materials and started making sawdust. Very quickly I realized that each individual part became the project. While I had started building it because I wanted to fly it, that feeling was quickly replaced by an urge to make each piece as nearly perfect as I could do. I knew the piece was part of my airplane, but I didn't look at it that way. I was just build-

George's Falco on the flightline at EAA AirVenture Oshkosh 2012. He shipped the aircraft in a crate to California where he put it back together and flew to Oshkosh. Flying from New Zealand was too big of a challenge, George said.

ing that one thing, which meant solving a lot of problems. It got to where I'd wake up in the middle of the night thinking of various ways of building something."

George started with the simplest parts he could: the tail surfaces.

"The tail ribs are truss types, which were fairly easy to build, but the spar has laminated caps and is routed: That's the first place I used the router on the airplane. Very quickly, it became the most used tool on the project. I continually found uses for it and built jigs and tracks to guide it."

All wooden aircraft have the reputation of taking longer to build because there are so many pieces, both large and small, to be fabricated. George, however, explained why it takes so much time in another way.

"Everything you do on a wooden airplane, especially one as sophisticated as the Falco, requires lots of tooling and fixtures. In fact, nearly every piece has to be built twice: first the tooling/fixtures, then the part. The fuselage frames, for instance, are laminated and have to be a specific shape, so you build a form for each of them. The fuselage has to be jigged on a fixture that holds everything in exact alignment while the skins are being glued in place. Some of the skins are compound curved, so you have to build a male mold to form the skin over. That molding process, by the way, was very rewarding, and I enjoyed doing it."

Every airplane has its share of things that are difficult, and in the case of George's Falco, it was the flaps and ailerons.

"The flaps and ailerons have to be exactly right. If they aren't perfectly straight you'll have problems rigging the airplane. For some reason, those on the left wing gave me real fits, and I had to build both the flaps and ailerons three times to get them right.

"The canopy itself came from the kit manufacturer, Sequoia Aircraft, but I modified it by raking the windshield back and raising the canopy three inches for more headroom."

Although the landing gear was available from the kit manufacturer, George did it in true homebuilder fashion and found parts that would work.

"The main gear is off of a MS-893 Rallye. I cut it and modified it to fit and had a friend do the welding. I ordered a nose gear from Sequoia, but just about everything else in the airplane are standard parts that I cobbled together to get right. The gear, incidentally, is actuated by electrically driven jack screws."

George's tidy cockpit controls and instruments.

This bird logo is George's reinvention of a Ferrari logo. Since the Falco is Italian in design and often called the Ferrari of light aircraft, he swapped out the horse for a Hawk (Falco in Italian) and added stars of the Southern Cross off the New Zealand flag.

Photography by Jim Raeder

The nose bowl was also a purchase, but George wasn't happy with it; so he modified it to his taste. The instrument panel, a place where builders really show their tastes, went through several iterations.

"I actually did three instrument panels. The first was very basic and analog. Then came the version that was built around a Dynon moving map display, and then the current one that uses a Garmin G3X."

George found an overhauled 160-hp Lycoming IO-320 and Hartzell prop that were fugitives from a Twin Comanche, and he retained the standard exhaust rather than going to something more exotic.

When it came time to fly the airplane, George said, "I read *Test Flying Your Homebuilt* and made up some test cards. Then I logged time in another Falco. I feel really strongly about getting time in the same type of aircraft, so nothing is strange to you. Many people don't do that.

"I tried to consider everything that could go wrong and have a plan for it since I knew, being largely a chicken, when I was lined up and ready to go, if I had a reason to back out, I would.

"The day dawned perfectly. Then, after all my taxi tests I was lined up for takeoff, and I tried to think of a reason to chicken out but couldn't. So, I pushed the throttle in. From that moment on, it was all business. All emotion was removed including elation. It tracked straight, lifted off smoothly, and climbed straight and true.

"I kept the gear down on the first flight, as I'd read that the main reason of the first flight was to land it safely. I climbed directly above the field and did some low-speed handling and stalling to get a handle on its approach configuration and calculated 1.3Vs based on what I was seeing. Then I made what's probably one of my best landings in the airplane.

"During the test and since, I cruise at 165 knots true at 8,000 feet. However, with the exception of the USA trip, I'm usually not above 1,500 feet where I see 155 knots indicated at 31 liters per hour. That's just over 8 gallons per hour. Its handling is pure Falco, which is to say positive, delightful, and easy."

The Oshkosh trip was something of an afterthought, but one that really got him focused.

"I was at AirVenture in 2010 and was standing at AeroShell Square when airplanes were taxiing out to leave on the last day. I watched and somehow felt that it was something I


George buttons up the Falco's canopy.

had to get involved in, so I started making plans that night to bring my airplane over."

The Paperwork

The problems of building an airplane are largely mechanical in nature. However, bringing that airplane in to tour the United States meant solving problems that, logistics aside, are almost entirely bureaucratic in nature and much more difficult to deal with.

George said, "The TSA [Transportation Security Administration] sees the airplane, more than the pilot, as the risk. However, if my airplane had worn a Canadian 'C' or a Mexican 'X' registration rather than a thoroughly unexpected ZK, it could have come in with no problem. Airplanes from those countries are apparently seen as no risk. All others have to follow some very strict rules. Unfortunately, the TSA regulations are written for larger transport and cargo type airplanes; they didn't expect to be dealing with a tiny Kiwi homebuilt. But rules are rules, so I had to jump through all of the regulatory hoops."

The rules include George having to list every single airport at which he would be landing, including weather alternates. Every leg, every flight had to be pre-approved. That's the reason he couldn't fly at Oshkosh for EAA's air-to-air photographers. Since he didn't know we would be asking him to make that flight, he didn't have it on his list. So, we had to be satisfied with static and detail shots.

"The TSA, not the FAA, controls what an airplane does in this situation and, not being aviation-oriented, they don't realize that they should have given more consideration to safety when making up their rules," said George. "If, for instance, I would have had a mechanical and had to divert to the nearest airport, I would have been in violation of federal law. They made it very difficult. However, once we got past all of the regulations, the trip was absolutely magic. The trip from Los Angeles, where we assembled the airplane, to Oshkosh was largely for transportation and a little rushed. However, the trip from Oshkosh back to Los Angeles was for ourselves, but at no time could we escape the magic of discovering America.

"On my first trip to Oshkosh I made a mistake and saw the airplanes but missed the people and the country. So, on this trip I was determined to see and get to know both as much as I could, given the time constraints. One of my very first impressions about America is that I'm luckier than many of her citizens because I've now seen so much of her beauty that is not seen even by those who live there. Traveling by small airplane removes the visual limitations imposed by roads and highways and opens up vistas that are not to be believed. In many cases I simply wasn't prepared for what I saw and experienced. For instance, until you're at 8,000 feet flying through Provo Canyon and the city of Provo, Utah, suddenly opens up in front of you, you don't know the feeling of being insignificant. This country is so huge, with so many different overwhelming sights and has so much diversity, that you're continually being challenged to take it all in and put it in perspective.

"I also think Americans have to be the friendliest, most upbeat people on the planet. It was amazing how people who had just met us were willing to stop what they were doing to help. The guys in Chapter 92 in Chino, California, where I did the assembling, for instance, went far, far out of their way to help us get the airplane together and on its way. At virtually every airport and small town where we stopped, someone would be there to help. They even gave us crew cars to go to town, or drove us in. The people were incredible almost everywhere we went.

Power for George's Falco is an overhauled 160-hp Lycoming IO-320 paired with a Hartzell prop. Both were "fugitives" from a Twin Comanche.

"I was amazed by the quality of airports at even the smallest towns. Although I heard local pilots complaining that they have to fight to survive, they can't imagine how much higher quality their airports are than most of the rest of the world. I also know many aren't happy with the FAA and the systems they've set up for aviation, but from what I've experienced elsewhere, I think every country should shut down their own airspace and regulatory systems and contract with the FAA to do them. America's systems work, and for the most part, are easy to understand. I was blown away by how friendly and efficient all the air traffic controllers were. They made what could have been difficult tasks, like figuring out LA's airspace, almost easy.

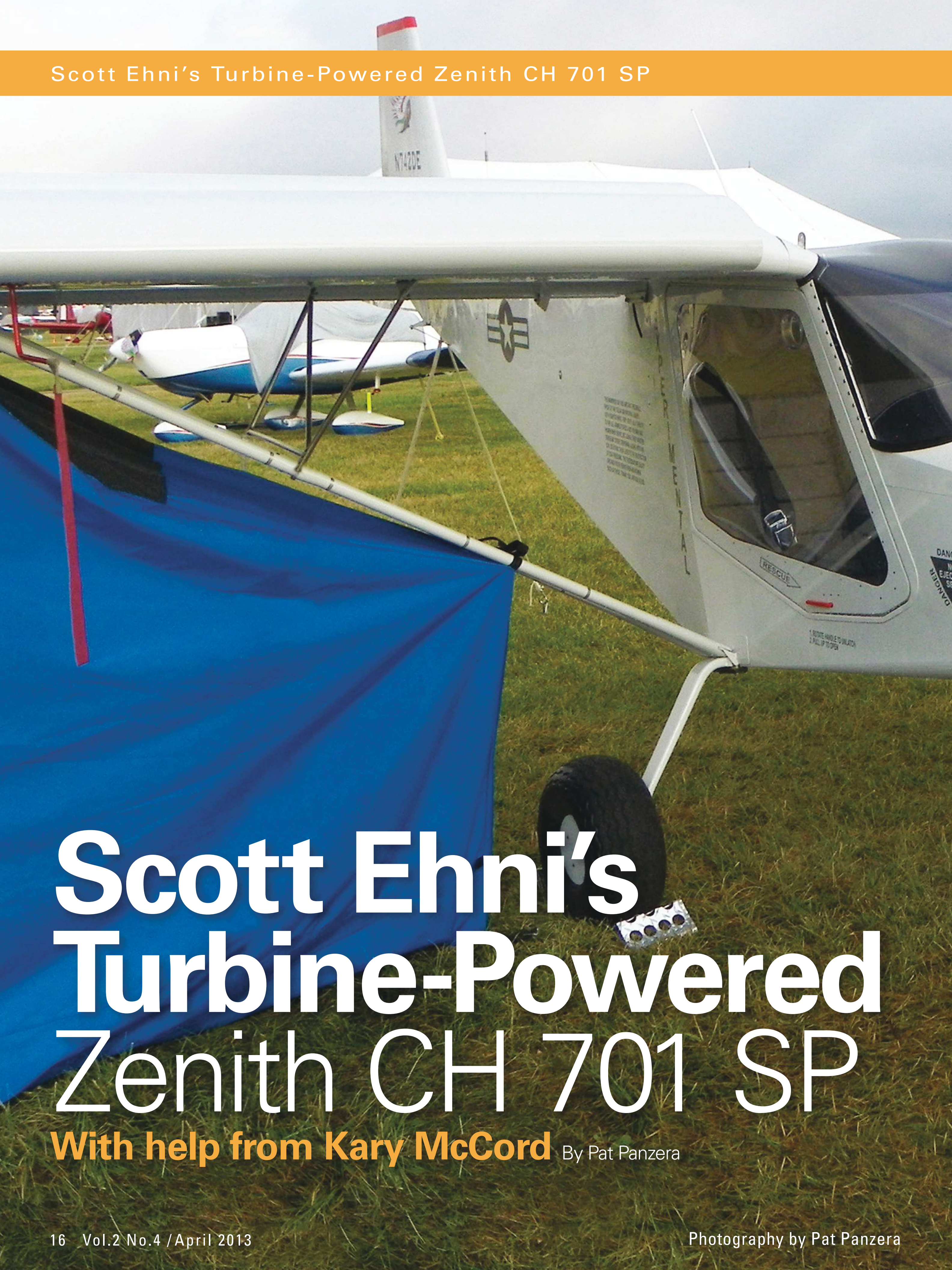
"And then there were the people at Oshkosh. It was everything I hoped it would be and more. I met a lot of people I'd only known via e-mail and formed some permanent friendships. In all honesty, I was a little uncomfortable with the bit of celebrity that my arrival from New Zealand caused: The interviews and such put me very much out of my element, but it was fun, nonetheless."

So, now that he has gone through what most people would have to categorize as an almost life-changing experience, what's next on his aviation horizon?

"While I was in LA, I picked up my next project, a 1979 Bellanca Viking. I've already taken it completely apart for re-cover and restoration. It's going to be a wonderful traveling airplane, but I already miss the freedom I had when building a homebuilt in the ability to make improvements. Being a certificated airplane, I now have to do some things that are clearly outdated, but in the end, I'll still have a good four-place airplane. Of course, when that's done, I'm certain I'll do another homebuilt. I just have to decide what. But it'll happen."

It's always gratifying to see our country through another's eyes. With all of the doom and gloom occasionally raining down around us, the truth is that we in the aviation community in the United States have it much better than so many others. Plus, regardless of what happens on the political front, it's impossible to physically change the land that is America. And it often takes nothing more than a Kiwi in a tiny wooden airplane to remind us of how great our country is. 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*.



Scott Ehni's Turbine-Powered Zenith CH 701 SP

With help from Kary McCord

By Pat Panzera

Photography by Pat Panzera

Scott's custom-made tent hangs from the starboard wing. The 701 has a distinctive profile.

Scott Ehni (pronounced ē nee), EAA 601854, has done something few people have, and most shouldn't. He successfully installed and flew a homebuilt aircraft with a turbine engine. The issue, however, is that it's not a practical installation and could be very expensive to duplicate if you don't have access to a shop like Scott's.

Why a Zenith CH 701?

Because the engine installation was going to be highly experimental, Scott and his friend Kary McCord wanted an aircraft that was durable, had good handling characteristics and, of course, a very low landing speed—one that was intended for off-field operations. All these features led to "something I'd feel safe in," Scott said. So, the decision was made to scratch-build the 701.

Modifications

Numerous tweaks to the design were justified based on two factors: 1) Scott wanted to reduce as much drag as practical; and 2) if he could sacrifice a little material for the sake of reducing build time, he did.

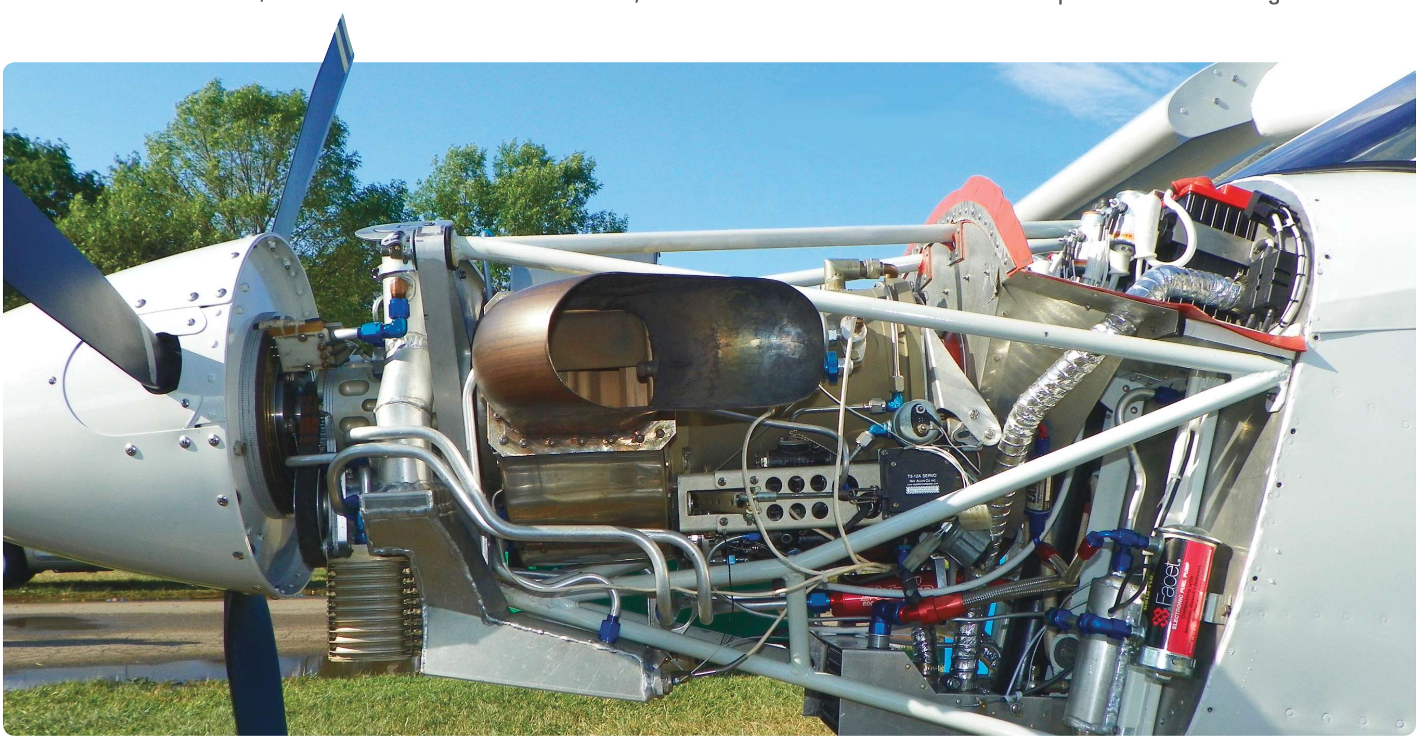
One mod that Scott is particularly proud of is the streamlined fairings they fabricated for the trailing edge of the round wing struts. While the round tubing is affordable and gives the best weight-to-strength ratio for this application, it's not very aerodynamic. Instead Scott devised an elegant method of using hose clamps to secure the fairing.

Another interesting mod crafted by Scott and Kary is the single-piece flaperon. The plans specify a two-piece arrangement, affixed where they meet in the middle, but with the outboard section being offset to cause the inboard section to stall first at high angles of attack. That gives the pilot good aileron control at low airspeeds and before a full stall. And once again, because of the manufacturing facility he owns, Scott was able to make the flaperon in a single piece and include some lateral twist to maintain the designed stall characteristics. The one-piece flaperon also eliminates the inboard/outboard connection hardware, some of which sticks out into the breeze, allowing him to reduce drag and weight.

The 701 normally has welded fuel tanks installed into the wing bay just aft of the spar. But this plane has "wet wings" (the structure of the wing is sealed and serves double duty as the fuel tank) to feed the thirsty little turbine (even though the skins are only 0.016-inch thick), holding about 21 gallons total with 9 of those gallons ahead of the spar. Zenith specifies the 10-gallon tanks be located behind the spar, with "long-range" tanks added to the next bay out, so as fuel is burned, the CG migrates. As Scott considered his options, he elected to add fuel to the leading edge (rather than the next bay), leading to minimal CG changes with fuel consumption.

Every part of the basic airframe was built by hand in Scott's shop—except the wheels/tires and nuts and bolts. The propeller and the engine core were, of course, built by others, but virtually everything else was fabricated in Scott's shop, including the polycarbonate (Lexan) windows. Ironically, Scott will say that the hardest task of the entire build was the bubbles in the doors. After contacting experts in the field to hopefully farm out that process, he was told specifically that it couldn't be done—that it wasn't possible to form a bubble in a flat sheet of Lexan and still be able to see through it.

Admittedly, Scott said they ended up scrapping about four sheets of Lexan in the process of making the



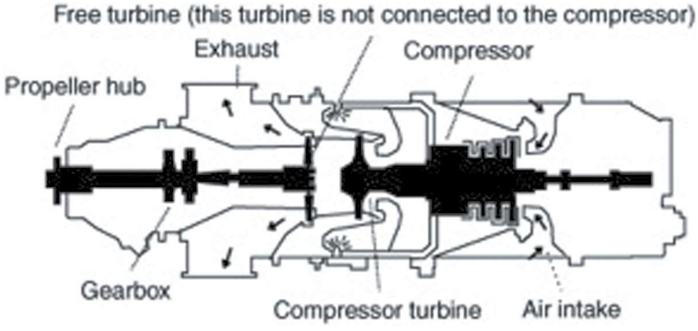
This side-view of the engine shows how tidy and well thought-out everything is inside the engine compartment. To read an alternative view about the use of turbine engines in homebuilts, read this article.

Photography by Pat Panzera

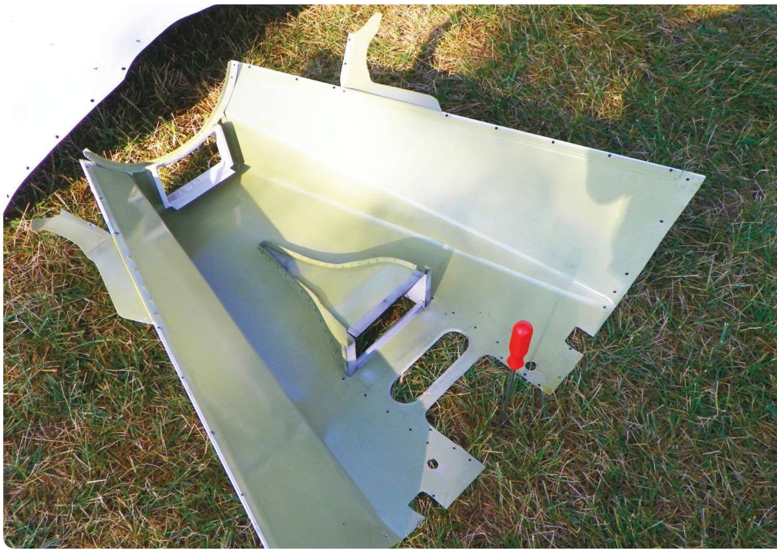
doors—but they got it done. And while it seems like a strange place for a bubble, it's not there to look through; it's there to allow more shoulder room. A bubble was also blown into the skylight to add a little stiffness. Normally, according to Scott, people opt for a thicker (0.09-inch) sheet of Lexan than what the plans specify to create the one-piece windscreen and skylight, to give the windscreen a little more rigidity. But Scott has proven that by adding some compound curves to the transition from windscreen to skylight, it stiffens the entire piece enough that thinner, lighter (0.04-inch) Lexan is sufficient.

The Garrett JFS 100-13A Turboshaft Engine

The turbine engine Scott chose, in its factory stock configuration, is a jet-fuel starter for an LTV A-7 Corsair II. It's designed to nestle up along the main powerplant, geared into the accessory housing, spinning the main turbine and thereby starting the engine. As a starter motor, as opposed to a ground power unit, it has some very distinct advantages, even though it's only designed to run for four minutes at a time. One, it's been tested up to 30,000 feet, and it has to be able to restart the aircraft's jet engine at those altitudes. It's also been designed (and tested) to a higher standard since it's an airplane part as opposed to a ground-based accessory; so it's a little lighter and has tighter tolerances. Most auxiliary power units are direct drive, whereas this is a "free turbine" that works more like the torque converter in your car, where the turbine disc driving the compressor rotates independently of the discs that power the prop. You basically have a combustion-driven fan blowing on the fan that spins the prop.



The advantages to this arrangement is the lack of a need to install a prop that's capable of feathering (although many will argue that a windmilling prop causes more drag than one that's stopped) and the fact that a smaller, lighter electric starter motor can be used since it doesn't have to be powerful enough to rotate the prop and any



The two-piece cowl is completely hand fabricated from sheet aluminum, including the blisters and louvers.

Details of the empennage, including gap seals and trim tab.

engine-driven accessories every time the starter button is engaged.

But there are changes that need to be made to this little turbine starter motor for it to spin a prop, and there are some features and details that need to be removed. The permanent magnet generator (PMG) is designed to power all the aircraft instruments and accessories while the engine is being started. Removing the PMG eliminates about 15 hp worth of drag from the little engine, in addition to its excess weight.

The original jet-fuel starter used some electric solenoids to control the fuel flow, and even though they are high-quality mil spec and Scott has never had one fail,

A simple but very useful instrument panel, including an Apple iPad. Sharp eyes might pick up the USB pen drive used for downloading flight data.

he didn't want to have to supply full-time electric power to the engine to keep it running. So he replaced $700 to $800 worth of electric solenoids with a single $70, high-pressure-brass, three-way valve rated at 3,000 pounds per square inch. The high side of the fuel pressure system only generates about 10 percent of that, so it should work for a long time.

The igniter that comes with the engine is designed to run off the PMG, and it requires some ridiculously high voltage and amperage. But to make the engine more compatible with traditional aircraft electrical systems, Scott opted to use a 24-volt igniter, wired into the start solenoid, so that it's only "igniting" when that solenoid is activated during the starting procedure. Once started the engine keeps running on its own flame front. An elegant feature of the starting system is the 50-percent switch. Upon hitting the starter switch, the engine begins to rotate. Fuel is then added and begins to burn, but once the turbine reaches 50 percent of its design rpm, it automatically shuts off the starter. The idea here is that the pilot can simply leave the starter switch in the on position, and in the event of a flameout, it will begin to restart on its own. Scott opts to switch the starter to the off position after the turbine is running, and has yet to regret it, even in light rain. They have no desire to fly in heavy rain.

Since this is merely a starter motor for a much larger turbine engine, the designers were more concerned with size and weight than they were with fuel burn efficiency. So the stock exhaust system is inherently inefficient. A new system was in order. The difficulty with this is that it had to be built and installed to exacting tolerances, being concentric within 0.001 inch. Welding 321 stainless can be difficult as it tends to "move around" according to Scott. So the process they chose to use was to fabricate it to the best of their abilities, heat it as an assembly to 1,400°F (the normal operating temperature of the part) over and over again to "season" it. Then once they were happy that the part had become stable, they machined it to fit the required tolerances.

When you combine these major changes, which also include Teflon-coating all the inlets, they were able to get more than 150 hp from this little turbine that's rated from the factory at only 90, with an 80-percent safety factor on the gearbox. But they limit the engine to 120 hp. The stock planetary gearbox that came with the engine, which converts the 72,500 turbine rpm to 3,000 at the prop, is really limited to 120 hp by design, and Scott doesn't want to exceed the recommended limits. The 120 hp is only used for extreme climb-out and is capable of taking the 701 beyond its redline at straight and level

Photography by Pat Panzera

flight, so there's no real use for the excessive power for extended periods.

The Conversion

A required mod for the engine conversion is the addition of an oil circulation system. As mentioned, the engine was only designed to run for four minutes, just long enough to start the big engine, so there is just enough oil in the engine to accommodate this function. Running it longer will require a system that will circulate the oil through a filter and a cooler. So a three-stage dry sump was added, with two of the stages dedicated to evacuating the oil out of the two gearboxes, with the third stage removing oil from the holding tank and pressurizing it before running it through a pair of aluminum coolers, then two filters and then back into the two gearboxes. The pump is custom made by Peterson Fluid Systems, using components designed for a single-stage NASCAR differential oil pump. Why two oil coolers? The primary one is for cooling the engine of course, but the second one is for cabin heat. At high altitude, it's nice to have warm toes.

The starter motor used on the little turbine is rated at 24 volts, as is the previously mentioned igniter. So to use it with a 12/14-volt electrical system, they call on a second 12-volt battery that can be switched from parallel to series (and back again) with the primary 12-volt battery. So when it's not called upon for starting the engine, the second battery becomes the backup for the avionics system. Both batteries are maintained by the B&C 40-amp alternator that was custom installed on the engine.

In the stock starter motor configuration, the fuel controller manages the engine up to an optimum rpm for spinning the jet engine it's trying to start. But as an airplane engine, it has to be modified for variable rpm. On this particular 701, the throttle operation is controlled by an electric servo (fly-by-wire if you will) from a momentary-on DPDT toggle switch on the stick grip—no actual throttle lever in the cockpit. Same for the propeller adjustment. So with one hand on the stick, the pilot can operate the throttle, prop, and pitch trim from three different switches, including a hat switch for the trim.

Scott also used the stick to control the mouse on the laptop that is used for in-flight data acquisition from the stick grip as well. The EIS Horizon screen reads out the engine as well as flight information. A Garmin 696 provides navigation info as well as weather. A Grand Rapids autopilot is installed to handle the pitch and roll axis and tracking duties as assigned from the Garmin.

The Propeller

The propeller is a vintage NSI unit. The NSI CAP 140 prop is in-flight adjustable (electric) and uses three Warp Drive composite blades that have been modified by the addi-

Scott in front of his turbine-powered Zenith CH701.

tion of an aluminum cuff that fits into the NSI hub and is capable of going "beta" to help the plane slow down; and in some cases, actually allow the plane to taxi in reverse. Admittedly, the NSI was giving Scott problems during EAA AirVenture Oshkosh 2012. Scott said that it "seems to have a mind of its own," changing pitch only sometimes. And of course, the propeller is the rpm governor, so pitch control is critical. Scott said, "Ironically, the only thing that's given us any trouble is something we didn't make." …Or modify. Scott seems to think that the issues with this particular prop is the bearings or the jack screw. "Something's binding—we've even gone through the trouble of installing dual contacts thinking that it might be an electrical issue." But that didn't help.

Performance

Flying out of Texas really isn't the best for turbines; they do better at high altitudes and cold air, and there's not much of that where Scott and Kary live. Average fuel burn is 13 gph, and at 10,000 feet they can expect a 60-percent drop in usage as compared to the same speed at sea level. The advantage is that at high altitude airports, such as Leadville, Colorado, where Scott plans to vacation, he'll still have 120 hp available at the 8,000-foot runway elevation, where a comparable piston engine may have only 60 hp.

A Grand Rapids Technologies EIS was installed to keep track of more systems than Scott could mention, including cowling temperature to monitor the temps "under the hood." Of particular concern was the throttle servo that may not be well suited for high temperature applications. But the highest temps recorded thus far have not exceeded 120 degrees, so Scott and Kary feel safe with the servo being located inside the cowl. In addition to this sensor, disposable temperature sensitive adhesive indicators (those designed to change color if an out-of-range temperature is sensed) have been located all over the engine compartment and checked after each flight.

And speaking of the cowl, it's all aluminum. The blisters on the cowl streamline the engine mount attachment points. So Scott had to build and learn how to use the English wheel to produce them.

Throughout the dyno, propeller, and flight testing, Scott and Kary were able to download the EIS stream to a laptop computer via a "Dogcatcher" RS232 serial data logger. With the help of a computer guru friend, the information is then displayed in an Excel spreadsheet for easy digestion. Scott learned early on that one can never have enough data. "You can always throw away the extra, but it's tough sometimes to get more," Scott said. These numbers were beneficial in proving the engine, keeping an eye on the possibility of bearing failures or other system malfunctions during the critical first few hours.

Future Plans

Plans are to eventually put the plane on floats, so if you look closely, very near the leading edge of the wing you'll notice two little tabs protruding from the interior structural tubing. They are there for two reasons. In the future Scott and Kary plan to mount the plane on floats, so these two, along with two others (aft of the cabin) are lifting attach points for hoisting the plane for the easy attachment and removal of floats. There is also a side benefit—the hangar is a little crowded, so the 701 gets stored overhead, suspended from these attachments. A rack that is adjusted for fuel loads allows the plane to be lifted level from just these two points that are obviously ahead of the CG.

Scott said that since he was a kid he's had an idea for an amphibious, four-place flying boat that he'd like to build, but he didn't want that to be his first project plane. So he built the 701 to get some good building experience with nearly guaranteed results. Scott also said that he'd begin working on the flying boat as soon as he got home from AirVenture 2012.

Can It Be a Practical Aircraft Engine?

Scott said that if this engine finds its way into a suitable airframe, such as any number of slick, fast aircraft like some of the scale Mustangs or even the smaller fast-glass aircraft that can work with 120 hp, then 200 to 230 mph on 13 gph starts to make a little more sense. Scott is currently working with a friend who is installing the JFS 100-13A in a single-place Midget Mustang (Long Midget). Bottom line? How else can someone log turbine time for $50 per hour?

Is there a future for small turbine engines in homebuilt aircraft? Not according to Scott. For him, the real future in aviation will be fuel efficiency, which except for extreme circumstances, a turbine will never be. Scott recommends looking further into electric flight for the real future of experimental aviation. EAA

In addition to being the past editor of *Experimenter* e-newsletter, the current editor and publisher of CONTACT! Magazine, and a regular contributor to KITPLANES, Patrick Panzera is an experienced homebuilder, EAA Technical Counselor, AirVenture forums presenter, and an instrument-rated private pilot.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Tony's Cub comes together, showing the structure of the front cockpit.

Tony Creasy's Carbon Cub EX

Helping a new builder

By Lisa Turner

When I talk to first-time aircraft builders, I begin by telling them my three rules of self-preservation. First, pick an aircraft that has been proven and builders have been flying; second, check out the kit manufacturer to make sure it is financially stable and will be around when you need it; third, call up three builders who built and flew the kit you are thinking of building and ask them how things went.

When Tony Creasy, EAA 758962, called me to ask if I'd be his technical counselor for a Carbon Cub build, I was thrilled. I knew about CubCrafters and its products, so I knew that Tony had met the self-preservation test. As an engineer, I am always trying to assemble a logical path to success. This may disappoint aircraft builders who take the meaning of "experimental" to extremes, but there are enough unknowns with even the best of plans. True experiments in flying machines are a critical component in flight design progress, but they are probably not the best choice for the first-time, weekend builder.

I followed Tony's directions through the mountains of western North Carolina to a grass strip in a private fly-in community called Tusquittee Landing. The small two-lane road twisted through forest and meadow with the tall Tusquittee Mountains rising steeply on my left. Hangars and homes dotted the length of the 2,700-foot, neatly trimmed grass strip on the right.

I found Tony in his hangar with boxes of parts and the fuselage next to a 1945 Piper J-3. As I took in the view, Tony came over to greet me. He pointed to the J-3 and said, "Have to have something to fly while building!" Fascinated, I asked Tony to tell me how he came to the Carbon Cub EX decision.

"Ever since soloing in a Cub, I have always loved tailwheel aircraft, especially the Cub. As nice as the J-3 is to fly, I really wanted more modern features—an electrical system, flying from the front seat, and a modern cockpit display."

Tony's reasoning resonated with me. I made similar choices for similar reasons in my own projects, opting for less "experimental" and more "known quantity." The ability to choose everything from colors to electronics and have them integrated into a stable and proven design is appealing.

As I gazed around Tony's hangar, it was clear that his passion for flying his J-3 and for assembling the airplane of his dreams was driving construction. Looking at the open parts crates, I asked Tony how he arrived at the decision to build the aircraft himself.

Several of Tony's avocations—woodworking and welding—gave him confidence when he first thought about building his own airplane. "I didn't even consider buying," he said. Where some builders are driven by the option to save money by paying as you build, Tony was driven by being able to assemble what he calls the "perfect combination" of features in the Carbon Cub—from a spectacular power-to-weight ratio with composite materials, to a modern and advanced electrical setup with glass cockpit instrumentation.

"My choice needed to accommodate two adults with pets and plenty of baggage. It had to be slow enough to enjoy the scenery but fast enough to make a reasonable cross-country. Flying off a grass strip and enjoying the mountain scenery is my primary joy. I also wanted to be able to convert from amateur-built to LSA to have an airplane I could age gracefully with," Tony said, flashing a happy grin.

Tony looked at a Mustang II, an RV, a Zenith, and the Rans S-19 before making his choice. He did not rush into it, and waited patiently for the ideas to gel. Tony said, "These were all beautiful aircraft kits that I had on my list; it was tough to decide."

In 2006 Tony attended the EAA Sport Pilot Tour at Gwinnett County's Briscoe Field. "I only looked at two planes that day: the Legend Cub and the new CubCrafters Sport," he said. "Although the Legend was a nice, modern version of my J-3, the CubCrafters somehow tugged at me: perfect fit and finish, flaps, and impressive performance from the same engine as the Legend (180 hp). It was also being built by a company that also produced a Part 23 airplane (Top Cub), so you would have some assurance that the company would be there when you needed them. I decided then and there, if they ever offered a kit, I was going to build one."

Tony and Lisa.


The Carbon Cub EX in its crate upon arrival at Tony's hangar.


Planning his panel.

Photography courtesy Lisa Turner

Tony's wish came true in January 2009, when CubCrafters announced the kit. Since he was still working full time and had long commutes, Tony planned the purchases of the components to begin in late 2010. His planning was impeccable; knowing that he could not devote all of his time to the project and managing the finances drove the stages of completion. "As much as I would have loved to buy the whole thing at once and just build and fly, the realities of work and other responsibilities meant I had to be patient," Tony said. Sound familiar?

As I completed that first visit to Tony's hangar, there was no question in my mind that Tony would be completing and flying his Carbon Cub on schedule. A neat layout of parts and tools, with detailed labeling, lined the wall next to the fuselage parts. If you have built an aircraft, you know very well that seesaw feeling of being torn in different directions with work and family schedules, which can derail a builder quickly. It's reported that less than 30 percent of kit buyers actually finish and fly their projects. Many projects get sold partially completed or end up sitting in a corner of the garage or hangar.

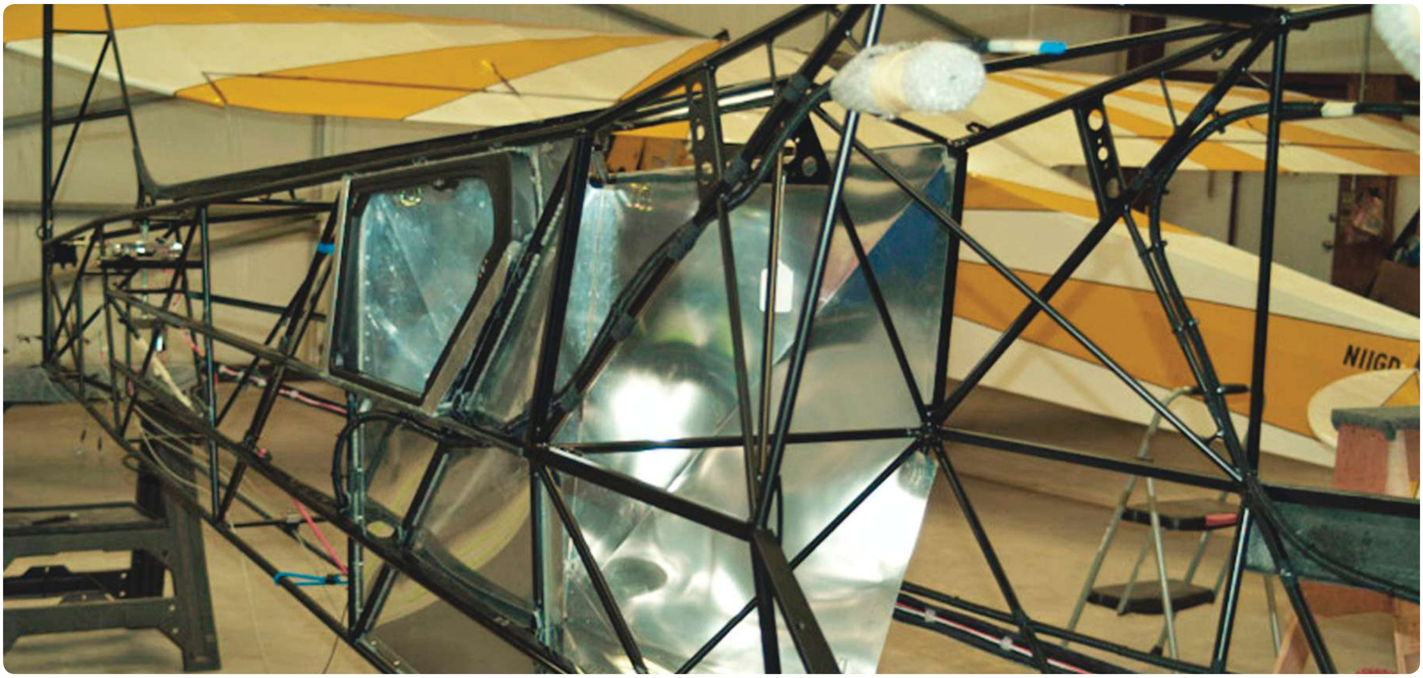
Not Tony. Six months later he completed the wings and began ordering more components. In April 2012, the last box of component parts arrived from CubCrafters. In June, Tony called me for fabric covering advice, and we went to Bipe Inc., a restoration facility nearby, for two days of hands-on practice with owner Jerry Stadtmiller, who also happens to by my husband..

Tony has now completed the fuselage structure, the extended baggage compartment, control cables and pulleys, installed the emergency locator transmitter, boot cowl, and fuel system, bringing the aircraft up to the fabric covering stage. Tony remains patient in his plan to be flying his Carbon Cub this year or next.

He said, "Although I am logging my hours, I decided at the beginning that I wasn't going to track progress or meet a timeline. A quality completion is much more important to me than meeting a deadline or comparing my progress against others."

I asked Tony what his biggest takeaway is from the experience so far as a first-time builder. "Two things," he said. "First, I had no idea how much fun this would be. I thought I was more of a flier than a builder, but this process has been therapeutic. Second, I am simply amazed at the quality and completeness of the kit. Support has been excellent for all my beginner's questions. Manuals are well written and understandable. To me and my mission, this could not be a more perfect choice." EAA

Lisa Turner, EAA 509011, is an aerospace manufacturing engineer who has built a Pulsar XP, a Kolb Mk. III, and the major portion of a RotorWay Exec helicopter. Lisa is a private pilot, A&P mechanic, and EAA technical counselor/flight advisor. In 2008 Lisa was the first woman to be named an amateur-built designated airworthiness representative for the FAA.



The fuselage aft of the tandem cockpit.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Safety in Experimental Aviation
Part 4

By Stephen L. Richey

As I work to compose this next installment, I am moved not only by aviation safety concerns but also by professional and personal reasons. I hope you will forgive me for going off topic for a moment. In a previous career, I worked on ambulances. In the past few weeks, my colleagues and I suffered a great loss. Two very bright young paramedics—both of whom I am proud to say I met and respected—were taken from us by a driver who made the conscious decision to drink and then drive. She ran a red light here in Indianapolis, Indiana, and crashed into the ambulance.

While not specific to aviation, this accident drives home the point that crash survivability is not something to be taken lightly and that what is learned from one field may be able to save lives in another field.

Our efforts in aviation could pay dividends beyond our immediate field, should we decide to apply the creativity and fortitude of homebuilders to the cause of safety and crash survivability. We only need the motivation to put it into practice. That said, this article is dedicated to the memory and honor of Timothy McCormick and Cody Medley. Rest well, men; those of us who are left behind will carry on the mission of looking out for our fellow man.

In the last installment of this series, we discussed the importance of adequate restraints in providing the best possible chance to survive a crash. One of the major issues with current aircraft and restraint designs is that they are designed for a set of loads that are unrealistic in terms of real-world crashes.

Table 1. Factors affecting tolerance to whole body deceleration	
Male gender	Increased tolerance
Increasing age	Decreased tolerance
Physical fitness (musculoskeletal particularly)	Increased tolerance; improves recovery times
Rear-facing seating position	Increased tolerance
Lateral-facing (sideways) seating position	Decreased tolerance
Underlying medical conditions (e.g., osteoporosis)	Decreased tolerance

This month we are going to look at exactly why there is such confusing, contradictory, and harmful misunderstanding and misapplication of data on this subject. This is important to understand before we get into the specifics of what may or may not be survivable.

The National Transportation Safety Board and the Federal Aviation Administration have often taken a stance that more or less could be summed up as "the best that can be done is what is currently being done." Several studies of general aviation crash survivability have been carried out. But, simply put, if you go in expecting no one to survive above a certain level and you have aircraft designed to fail more or less catastrophically at that point, you are likely to get data that says the "survivable threshold" is somewhere around this point.

The problem is that you are likely looking at the limits of the aircraft and not the limits of the occupants per se. Muddling these two intertwined limits is dangerous. While much has been written about the "human limits" to deceleration being fixed at a particular level, it is important to remember that there are several factors that change the tolerances to impact. These are spelled out, in a simplified way, in Table 1.

What a reasonably fit pilot or passenger can tolerate in a forward-facing position is difficult to correlate with any degree of certainty. One cannot, thanks largely to the ethical prohibitions against endangering the lives of experimental subjects, determine this through crash testing. Even using anthropomorphic test devices (crash test dummies), you have to have some "real-world" human data to validate the crash test dummy against. Such is the cycle that many in the aviation community are stuck in when it comes to where to pin their design points.

This brings us back to the problem of where to get data to validate our test devices. Given the design limits of aircraft being set so low, we can't look in a broad way to our own colleagues' misfortunes to provide a good measure. While it is important to look at previous aviation accidents/incidents, it is also vital that we do not put so much focus on them that we lose sight of data from other sources that may indicate something other than human tolerances is skewing the data. Thus the question arises, "Where to turn next?"

While the immediate temptation might be to look at passenger car occupant protections, if one is looking at determining what the upper threshold for survival is, albeit with serious injuries, the best place to look is probably professional auto racing. Living in Indianapolis, I have had the chance to meet several drivers. When they learn what I do for a living they often joke about being "live crash test dummies" because of the intensity and well-documented nature of their crashes.

One of the potential limitations often brought up about the broader application of auto racing crash data to other applications is both the physical fitness of the drivers and the younger age of those drivers. While the former is definitely a valid point, the latter is probably overstated, as there are numerous drivers in their forties (such as Joe Nemechek and Michael Schumacher) and even a few in their fifties (Bill Elliott and Mark Martin). Also, if we are going to design our aircraft to protect occupants, we have to consider that many of us will be hauling passengers younger than ourselves. If we design to protect those folks, then we can ensure that those who are less tolerant have a "margin of error," so to speak.

A few other factors come into play with regards to the severity and nature of injury produced by accelerations. Among these are the duration of the acceleration. Most crash impulses have durations of a quarter of a second (or 250 milliseconds) or less. The general rule is that the shorter the impulse, the better it is tolerated. This is why, for example, an aerobatic maneuver pulling 8*g* to 10*g* for a few seconds can cause unconsciousness and possibly a crash, but a similar impulse for 250 milliseconds in a crash impact would likely have little to no effect on most occupants, unless the cockpit structures or restraints fail.

How rapidly the impulse is applied (rate of onset) is another factor that can determine the nature of injuries sustained. Assuming the same magnitude (how many *g*'s are applied) and duration, impulses with a slower rate of onset will tend to be better tolerated. This makes sense if you think of crashes as being a series of inertial changes (more on this in a minute).

The other point to keep in mind is that the direction the forces are applied will have a significant factor on how well one tolerates abrupt deceleration. While there is a fancy engineering vector system based off of a three-dimensional coordinate map, almost everyone—including engineers—in all but the most formal of settings uses what might be best called the "eyeball" method. Keeping in mind Newtonian physics (specifically the first law of motion), objects in motion tend to stay in motion until acted upon by an outside force.

When applied to the eyeballs, which are not all that firmly anchored in the orbits save for a few muscles and the optic nerve, it means that the eyeballs will—at least for a split second—continue moving forward until their "tie-down straps" are stretched to the point that they counteract the movement. That is why if you are in a car and slam hard on the brakes it would be considered an "eyeballs out" deceleration (or negative acceleration). To answer the obvious question: It is at least theoretically possible to decelerate rapidly enough in this direction to literally tear the eyeballs out of the skull. I have seen a lot of extreme trauma in my research experience, but I have never seen it actually happen so far as could be reliably determined.

If you are facing in the direction opposite you are traveling, the deceleration would be considered "eyeballs in." If you were a World War II paratrooper riding in a C-47 looking sideways across the aircraft when it suddenly slows, then you would have an "eyeballs right" or "eyeballs left" deceleration, depending upon which side of the plane you are sitting. Just remember that the eyes keep moving, albeit briefly, in the direction you were traveling before the situation changed.

When it comes to vertical accelerations (both positive and negative), the results are a little different. The best way to visualize it is to think about the "stomach jump" you feel when you hit turbulence or ride a roller coaster. What is happening is actually the opposite: Your stomach (or in this case, the eyes) is staying put for a split second in terms of its relative vertical position. Hence, a vertical impact as we think of it in the aviation community (so long as the aircraft is not impacting upside down) is an "eyeballs up" deceleration. Welcome to the principle of the inertial response.

It might seem odd that we are judging this in reference to something moving opposite the applied acceleration. (Remember that an acceleration is not necessarily an increase; it is simply a change in velocity, direction, or both.) The reason for this is that, in the vast majority of cases, what causes injury is the body's inertial response to it, and not the acceleration itself.

That brings us to the final point one needs to understand to grasp and apply human tolerance factors. As pointed out in Table 1, an "eyes in"/rear-facing deceleration is the best tolerated. This is why, if your design will tolerate it, you should strongly consider using rear-facing seats for nonpilot occupants. Forward-facing seats are less well tolerated; but obviously pilots need to see where they are going, so we are restricted in this particular regard. Traditionally, sideways-facing seats (which produce lateral loads during crashes) have been viewed as being the least well tolerated. However, some crash data from the Indy car circuits have called this into question.

The next article in the series will look at the longitudinal ("eyes in" and "eyes out") events.

Until then, fly safely. *EAA*

Stephen L. Richey is an aviation safety researcher who has been involved with flying for the better part of two-and-a-half decades, starting with his time as a "junior hangar bum" with a local EAA chapter while a child in Indiana in 1988. He has logged about 700 hours thus far, including time in ultralights and as a perennial student pilot in light singles. His current project is the design of a new homebuilt known as the Praetorian.

Inexpensive Rivet-Removing Punch

Make one yourself

By Cy Galley

Many squeezed rivets are removed by drilling a hole in the rivet head, and then a pin punch is inserted into the hole and used to snap off the manufactured head. A single pin punch can cost $8 to $10, and it might not have the fit you need. Then, again, you might have a pin punch set but not have the size you need. Or perhaps you'll have to order a punch and wait for it to be delivered. The pin punch should be the same size as your drilled hole.

Without realizing it, you probably already have a ready stock of the high-grade steel of the precise diameter you need to make your own punch. A broken drill shank of the required size and your favorite file or die handle, or even a wooden dowel rod, will do the trick.

This drill shank was fixed in the handle by using "flox" (cotton fiber and epoxy) inside the handle. Then to complete it, the tip square at the end was ground to get a nice clean fit as well as a bit of a biting edge inside a newly drilled hole in the rivet head.

Remember, if you bend or break it, you can always make another. You can also make a pin punch of most any size using this method. Make the handle of aluminum or steel rod so you can hammer on it. Voilà, a homemade 3/32-inch punch.

Got a tip for your fellow builder? Send it to *Experimenter* at experimenter@eaa.org. EAA

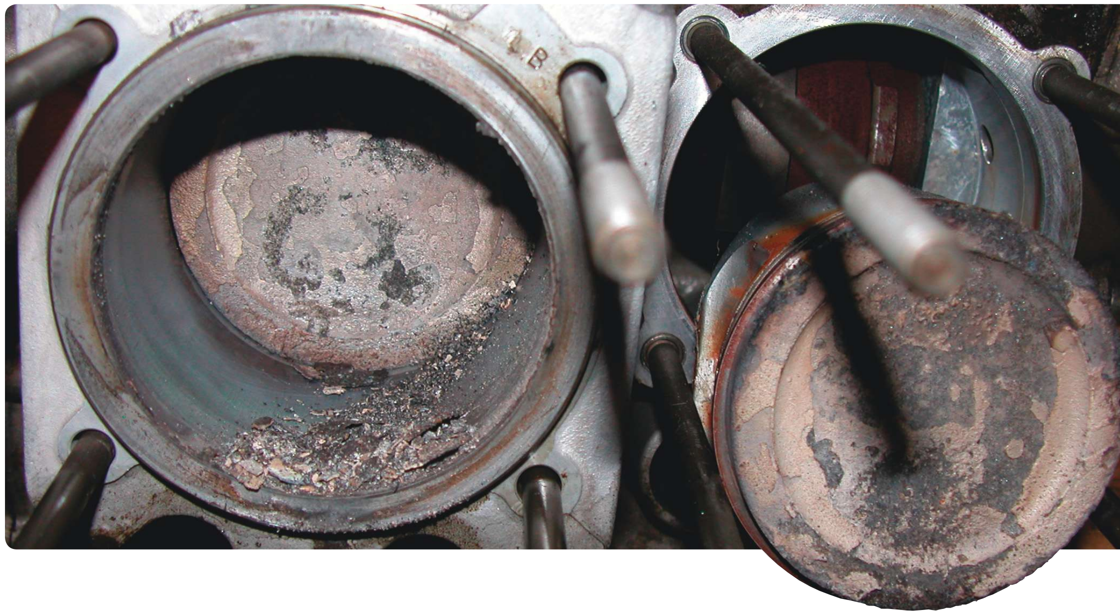
Hints for Homebuilders Videos

Bending Wood Capstrips

In this video, Earl Luce demonstrates an easy method for pre-bending your wood capstrips. Earl is an EAA SportAir Workshop instructor and a volunteer EAA Technical Counselor.

Composite Fairings Made Easy

Almost every project requires making some special composite fairings. In this episode, Wally Anderson demonstrates how to fabricate a quick and easy composite fairing. Wally is an EAA technical counselor.



Although Rotax approves the occasional use of 100LL, a steady diet will build up deposits like these.

Buying a Used Rotax Four-Stroke Engine

What you need to know

By Tim Kern

With a quarter century of history now behind the Rotax 912 series engine, it's time for a primer on what to look for when one enters the potentially dark world of used engines. Although all the usual used engine caveats pertain (see *Experimenter*, March 2013, page 36), there are some Rotax specifics, as well.

The series has three basic models: the original 80-hp 912, the 100-hp 912S, and the 115-hp turbocharged 914. The fuel-injected 912iS was introduced in 2012 for original equipment manufacturer (OEM) use only; it's unlikely you'll be buying a used one out of an airframe anytime soon. The 914 is a lower-compression 80-hp 912 with a turbo. In this article, we'll ignore the turbo; turbocharger inspection is best left to a qualified shop.

Such high-output, high-rpm, small displacement engines are mated to gearboxes that make this formula work. The Rotax is happy cruising at 5,000 rpm; a sure way to destroy it is to "lug along" at 3,800. The gearboxes, too, have their demands and personalities.

All Rotax units are designed for long life and reliable operation, but they are distinctly intolerant of misuse, clumsy operation, or neglect.

Your First Look

As with any used engine, the history, especially the recent history of the engine, is a big deal. How recently was it flying? How was it stored since then? Mark Paskevich, president/owner of Rotech Research Canada Ltd., the factory-authorized North American distributor for Rotax aircraft engines, said, "The most important thing is the pedigree. What documentation can you find? What's the level of compliance with Rotax service bulletins and airworthiness directives? Go through the logbook, see how meticulous service was, and note who did it." Rotech's website, www.Rotax-Owner.com is a comprehensive and free website. Register and enter the serial number of your engine, then print all the updates. Cross-reference your engine's documentation with those documents, and see if your engine is in compliance.

Ideally, you'll see the engine on the airframe. If this is a homebuilt, how "factory" is the installation? Is the oil cooler mounted correctly (with the outlet fitting at the top); are other lines connected to the appropriate outlets—forward or rear—on the engine? Is the oil tank installed so that it keeps the oil level between the inlet of the oil pump and the

Photography by Tim Kern

Even momentary oil starvation can lead to a ruined cam and case. For experimental use, some shops will line-bore the case for replacement bearings; this fix is not permitted officially and cannot be used in certificated or light-sport aircraft applications.

The right oil, clean and always available, will help prevent such expensive and dangerous destruction.

centerline of the propeller shaft? Too high, and oil can start to siphon from the oil tank, overfilling the crankcase when the engine stops; too low can let the lifters go flat or cause very noisy and expensive trouble.

Look for coolant and oil leaks. Water pumps—anything with moving parts that go through the case—wear out, and their seals are usually the first indicators. Likewise, check external hoses and lines. Look near the fittings to see if there has been crushing, scratching, or other abuse.

How old is the engine? Not just total hours or hours since "rebuild," but total months since new? Oft-overlooked maintenance includes routine replacement of parts, regardless of use. For example, Rotax recommends a five-year replacement of everything rubber, from seals and lines to the carburetor boots. Likewise, five years for the fuel pump. (In experimental use, you may want to consider replacing the standard pump with a longer-life unit, such as the Billet pump and regulator). Disclaimer: The maker is a client of mine, but I shouldn't *not* mention it. It's a good and proven alternative.

The Rotax four-bangers are finicky about what fluids are in their systems. Everything matters: fuel, oil, and coolant. They can use 100LL, but prefer unleaded premium, nonethanol auto fuel. A diet of 100LL requires doubling oil changes and frequent cleaning of the oil swirl tank. 100LL leaves deposits that will eventually accrue inside the engine (see photo).

Unleaded premium auto fuel that does not contain ethanol is difficult to find (links below), so many users simply burn enhanced fuels. Corn-fed fuels aren't as stable; over a very short time, they absorb water from the air. They also evaporate quicker (leaving a lower-octane fuel behind), and they tend to "sludge up" faster, making frequent flying a (pleasant) mandate. Again, the airframe logs will give you useful information. And knowing what fuel the engine has ingested is critical.

Even the oil used in the (oiled-foam or K&N-style pleated) air filter is prescribed. And the engine oil is critical—regular "aero" oils and automotive oils with "friction reducers" are not recommended. The Rotax-Owner.com website keeps an updated list of workable oils. The oil filter looks like an automotive unit, and many car-type filters will "fit." But only the Rotax unit will "work."

While you're looking at the seller's shop, notice the parts cleaning tank and find out if he has used it to clean oil lines or coolers. If he has, he has introduced "swarf" into the system. The cleaning tank is full of destructive abrasive waste, and washing other components in the same tank can ruin engines. Filter or not, everything in the sump of that parts tank can potentially get into the engine's bearings. I'd go so far as to recommend against buying this engine, unless you plan on getting it only as a core.

Rotax has made many running changes to these engines over the years. Some of the changes are mandatory; some are merely improvements. They cover everything from oil dipsticks to rocker arms to coolant tank cap pressure. You certainly can check, using the *Rotax Line Manual*, but the best way to be sure everything is up to date is to see that routine work was done regularly at a Rotax Service Center.

Here are a few tips about how to recognize updated parts: The cad-plated starters are newer, have higher torque, and are recommended for any 912S. The black-top carbs are newer than the cast ones. Square-top dipsticks are mandatory. Rotax increasingly recommends use of safety wire. It won't hurt to safety everything that could conceivably work loose or fall off.

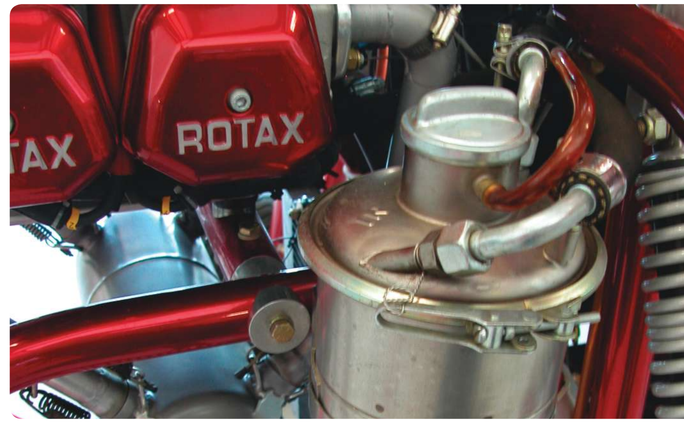
Fuel and oil lines that aren't properly routed or secured can cause trouble. Though of course you'll do it right, if the seller didn't, he may have done other things wrong, too. Paskevich said, "If a guy's taking shortcuts, you wonder what he's doing on the more complex or more expensive tasks. And look at the airframe logs; you may find things there that aren't in the engine logbook. You may find 'interesting' entries and gain some idea of how the engine has been used. Maybe you'll find a prop replacement. Was there a prop strike?"

Keep in mind that most airplane engines in noncommercial use will rust or corrode to death long before they reach TBO. Frequent flying, with thorough and routine maintenance, is the best engine life extender. A look through the logs helps ask the right questions.

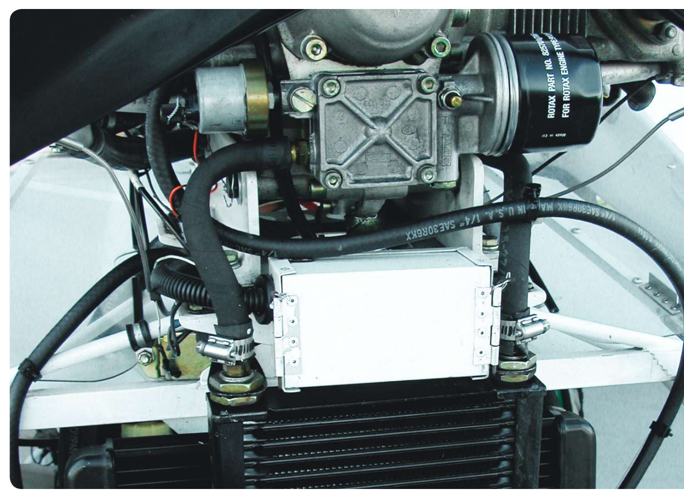
Disconnect the ignition and turn the engine over by hand to feel for any "flat" cylinders. Sitting for an extended time can allow the hydraulic lifters to drain, and once they do, they rarely pump back up. It may not be the lifters, either. You may get lucky; you may not.

Additional Paskevich advice: "Look at the prop. Is it damaged, chipped, repaired? Has it been dynamically balanced?" The gearbox's magnetic plug may tell you something useful. Look. If it was cleaned, say, 50 hours ago and now it's covered with metal, that's not good.

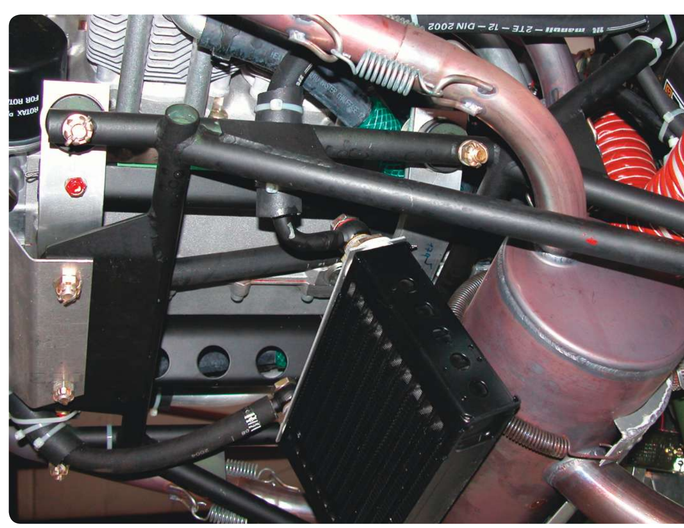
"If you can get access, look at a cam lobe. (You'll have to pull a cylinder.) I've paid to partially disassemble an engine, and it's the best money I've ever spent. You'll want a qualified tech to look, if you can get a compliant owner. Maybe you'll spend a few hundred bucks; that's better than a $10,000 parts bill, later. If the paperwork is poor, you'll want to do this." If the logs are incomplete or don't look right and



Proper location of the oil tank is critical. Each installation is unique. On this Powrachute, locating the tank is simplified, since the powered parachute does not go through radical pitch or roll changes.



Steve Swift's Kolb installation demonstrates proper orientation of lines—plenty of space.



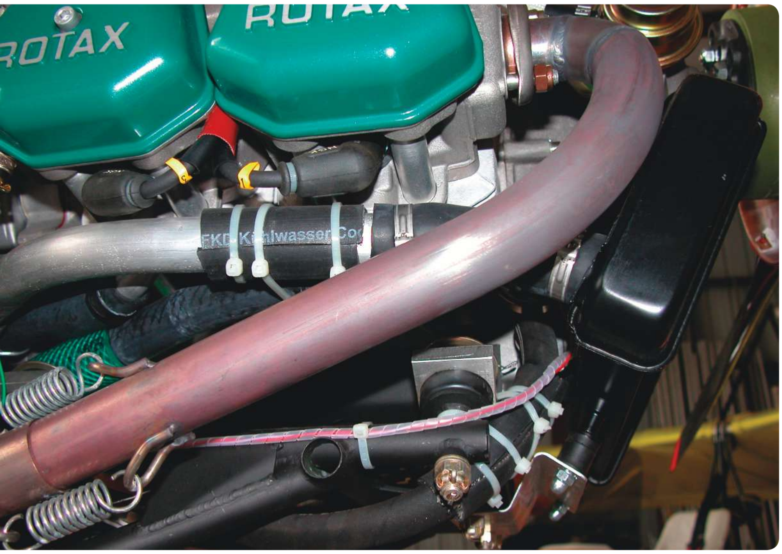
A cooler this close to the muffler won't cool very well and may encounter interference in operation. In cold climates, it's better to incorporate an oil thermostat (Varitherm) in the system.

the owner won't allow you to pay for an internal inspection, consider walking away.

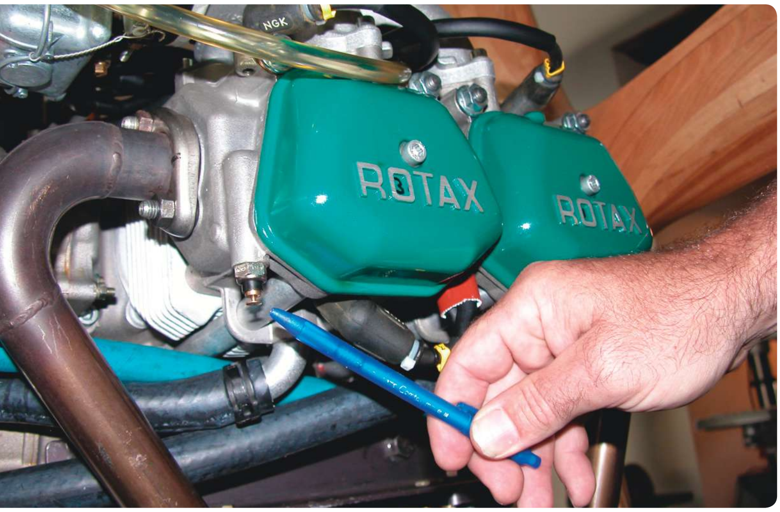
"If the engine looks rough or is badly out of tune—you may see exhaust system cracks and chafing, worn engine mounts—it's probably been a shaker and won't be in good shape internally, either. Ask the owner how he syncs his carbs. 'Visual' isn't a substitute for 'vacuum.'"

Okay, You've Seen the Logs

You've seen the logs and checked for AD compliance and made an overall external inspection. So far, everything looks good. What now?



Mounting components too close to one another can cause interference and damage in flight.



A common failure happens when this temperature sensor melts or gets crushed. It's easy to check.

Have the owner start it. Is there water in the gascolator? (Water, if it gets into the paper element of a fuel filter, can create mush that can plug the carburetor jets.) Watch to see that he checks the oil and that he "burps" the oil tank. What is the idle rpm? If it's below 1,400, you can expect shortened gearbox life; 1,800 or higher is okay. Brakes are cheaper than gearboxes.

A proper compression check comes only with a warm engine. Immobilize the prop with the piston at top dead center (TDC) on compression and introduce air at 80 pounds per square inch (psi). More than 25 percent leakdown demands a closer look. A simple cranking pump test should give you 130 to 174 psi (depending on model), with less than 30 psi difference among cylinders.

Certain items are life-limited by hours. In the experimental world, that's "on condition," but don't ignore anything. Once wear starts, it can progress rapidly, and a failing part can do a lot of expensive damage to "innocent bystander" parts inside that engine.

Even when you get a good engine, treat its first run after installation exactly as a new engine. Change the fluids and use the right ones. Use unadulterated premium auto fuel, and don't let it sit in your tank and carb bowl too long. Fly it, for Pete's sake!

Absolutely, positively pay attention to www.Rotax-Owner.com. Once you register, you'll get free e-mail notification of all factory service bulletins and airworthiness directives that might be released on it. The site's detailed videos show how to perform many important maintenance and tuning tasks.

Most importantly, as in flight, follow Cowan's maxim: Never let a known problem continue. If you know something is wrong, fix it.

For more information, register at www.Rotax-Owner.com. A broad expanse of knowledge is there. The *Rotax Line Manual* is available here.

Find ethanol-free gas (by state): www.Pure-Gas.org; www.BuyRealGas.com. EAA

Tim Kern is a private pilot and has written for more than 40 different aviation magazines. He was a key builder on two aircraft projects and has earned the title of certified aviation manager from the NBAA.

All-composite Alpha trainer built in Slovenia by the motorglider manufacturer Pipistrel.

Low-Cost Light-Sport Aircraft

They do exist!

By Dan Grunloh

There has never been a time when light-sport aviation enthusiasts have had so many choices. More than 130 light-sport aircraft (LSA) designs have been offered, and at least 100 are in active production. With much of the publicity on special light-sport aircraft (S-LSA) focusing on the high-priced models, it's only fair to put the spotlight on some of the more affordable options.

Manufacturers are responding to downward pressure on price by offering simpler models with fewer frills. Major air shows and aviation trade shows are a good place to find bargains as dealers need to move their stock to make way for the latest models. The pre-owned LSA market is also very lively, with amazing deals being completed that never make it to the public sale arena. Some of us might think we could never afford a new LSA, but in aviation as in life you should never say never, or you may miss your dreams. Here is a sample of five low-cost LSA in the under $100,000 range.

Pipistrel Alpha Trainer – $85,000

Carbon-fiber composite construction is often reserved for high-performance and luxury LSA where light weight is important and where the extra cost is worth the benefits. The European motorglider manufacturer Pipistrel introduced the Alpha trainer, which is based on its previous Virus SW model, and brought composite construction and fuel efficiency into the lower price range. It's designed for training, but those same features of ruggedness and low cost are also appealing for purely sport use. With an 80-hp engine and basic instrumentation, you get the kind of fuel economy and performance that previously cost much more.

Photography by Dan Grunloh

The rugged, all-metal Vision LT features a 48-inch-wide cockpit.

Cruise is 108 knots at 75-percent power. Empty weight is 615 pounds, and payload is a whopping 597 pounds. Endurance is 4 hours (with 30-minute reserve) on a meager 15-gallon tank. Get more info at www.Pipistrel-USA.com.

Vision LT – $84,995

All-metal airplanes have been the standard for performance and longevity for decades, so it's natural that metal construction dominates the LSA market. The Vision LT is a new LSA coming from the World Aircraft Company of Paris, Tennessee. The all-metal high wing is optimized for STOL flight and for superior visibility. The Vision LT is a derivative of the original Spirit LSA introduced in 2011. It was described as the culmination of 45 years of aircraft design by MIT-trained aeronautical engineer Max Tedesco from Colombia, South America. He wanted an airplane with a large cockpit that was rugged enough for use in flight schools. The Vision takes the original Spirit airframe and opens it up dramatically by narrowing the instrument panel and redesigning the doors.

Climbing aboard the 48-inch-wide cockpit is easy because the control stick folds flat for entry into the cockpit and because the lower front door openings extend well forward. The cockpit view is reminiscent of a helicopter, thanks to the shape of the instrument panel, offering amazing downward and forward visibility. Originally, airframes were to be produced in Colombia and assembled here, but now all manufacturing has been moved to a 22,000-square-foot manufacturing facility in Paris, Tennessee.

Tecnam P92 Echo Light

The Vision LT has a slightly thicker wing than the standard Vision and features stall strips to yield a full-flap stall speed of 28 mph. Cruise speed is 110 mph and the useful load is 565 pounds. The price includes a Dynon EFIS, Garmin transceiver, and custom analog instruments.

Major air shows and aviation trade shows are a good place to find bargains as dealers need to move their stock to make way for the latest models.

Tecnam P92 Echo Light – $74,999

Tecnam, a manufacturer of mostly metal LSA made in Italy, introduced a low-cost 80-hp version of its P92 Echo Classic that goes for $74,999 flyaway from the Hanover Airport in Richmond, Virginia. Its 100 pounds lighter than the standard Echo Classic that costs $35,000 more, proving the old adage that aircraft are priced by the pound. The starting price gets you day analog VFR flight and basic engine instruments. Adding a radio, lights, transponder, and a second fuel tank brings the total to $86,650. It has electric flaps, dual throttles, adjustable seats, and hydraulic brakes controlled by a central hand lever. The maximum takeoff weight is 1,102 pounds and the payload is 496 pounds. Maximum level speed is 103 knots and economy cruise is 92 knots. Tecnam is the world's largest producer of sport class aircraft. Tecnam hopes the P92 Echo Clas-

The steel tube and fabric Apollo LSA was inspired by the Avid and Kitfox designs.

Paul Mather flying the Breese 2 S-LSA at EAA AirVenture Oshkosh 2012.

sic Light will appeal to budget-conscious buyers who want a metal airplane from a major manufacturer.

Apollo LSA – $67,500

Steel tube and fabric airplanes have been the heart and soul of sport flying since the introduction of the Piper Cub. The Avid Flyer introduced by Dean Wilson in 1983 has inspired many follow-on varieties, including the factory-built Apollo LSA from Hungary. It brings the basic Avid or Kitfox type airframe up to the ASTM standards. Available for some time overseas as the Apollo Fox, the U.S. version (the Apollo LSA) has been given a taller vertical stabilizer and control surface gap seals to improve the handling. Most hardware was changed from metric to AN aviation grade for easier maintenance. Maximum takeoff weight is 1,260 pounds, and with an empty weight of 715 pounds, the Apollo LSA has a useful load of 550 pounds. It can cruise at 98 knots on 75-percent power, and the ready-to-fly price is $67,500 with the 80-hp Rotax engine and $69,950 with the 100-hp Rotax engine. Learn more at www.SilverLightAviation.com.

The Aerotrek A220/A240 – $84,500

Another economical choice in the tube-and-fabric, folding-wing format is the Aerotrek A220/A240, built by Aeropro CZ in the Czech Republic. They have produced about 200 aircraft since the 1990s. The 100-hp Aerotrek has a maximum gross weight of 1,320 pounds, a typical empty weight of 655 pounds, and a useful load of 580 pounds. Aerotrek is available with tricycle or taildragger gear, has a long list of attractive features, and is priced at $84,500.

American Bargain S-LSA

If you want a U.S.-manufactured S-LSA in the tube and fabric class, consider the 100-hp Rans S-7LS Courier with a flyaway price of $87,500 or about $95,000 with lights and a deluxe analog instrument package, or the Kitfox S-LSA with a base price of $95,000.

M-Squared Breese 2 – $34,995

Paul Mather of M-Squared Inc. has retained the feel and the fun of ultralight flying with the factory-built Breese 2 S-LSA that can be used for hire, training, or just plain fun. Simple, proven construction methods yield a tough airframe that can take abuse. A 65-hp Rotax 582 engine at 75-percent power with a Warp Drive prop will yield a cruise speed of 65 mph and maximum level flight speed of 74 mph. The company website proclaims, "An M-Squared aircraft isn't fast…It's fun!"

Empty weight is 565 pounds, and maximum takeoff weight is 1,320, leaving an astounding useful load of 775 pounds. Check the math if you don't believe it. Takeoff distance is 165 feet. The Breeze 2 is the lowest-priced fixed-wing S-LSA on the market, and Paul says you can actually make money with this aircraft. Learn more at www.MsquaredAircraft.com.

Challenger XS-50 (Kit With Engine) – Under $30,000

The Quad City Challenger is not an LSA, but the popular amateur-built aircraft deserves to be mentioned in any list of low-cost aircraft for sport pilots. Thousands have been built and flown, and builder support is plentiful. Assembly time is 300 hours, and most of the components are already built. The Challenger XS-50 and XL-65 are outgrowths of the Challenger LSS, designed for the United Kingdom and overseas market. It features a new tail and rudder and has differential ailerons. The XS-50 is a short-wing (26-foot) version with a top speed of 95 mph. The XS-65 is a mid-sized, 29.5-foot wing for floats, heavy loads, and high altitudes. Replacing the 17-gallon main fuel tank with 20 gallons in wing tanks opens up the area behind the seat for baggage and raises the gross weight to 1,060 pounds. The empty weight of 475 pounds allows for a payload of 585 pounds.

The pre-owned LSA market is also very lively, with amazing deals being completed that never make it to the public sale arena.

This look at a few low-cost, light-sport aircraft doesn't even cover weight-shift trike and powered parachute S-LSA, where costs are significantly lower across the entire spectrum! How about a U.S.-manufactured Northwing Scout XC trike with 80-hp Rotax full fairings and a topless, strut-braced wing starting at $49,000? Precision Windsports offers S-LSA trikes from Airborne Australia in the range of $38,000 with a Rotax 582 engine to $55,000 with a Rotax 912, not including shipping. Powered parachute fans should check out the Predator and Powrachute for details and even lower prices.

Browse the ads at Barnstormers.com to see prices for lightly used LSA that are much lower than you might expect. The S-LSA of today are going to be around for decades, but there is one important difference compared to standard category aircraft. Most, if not all, will eventually end up as experimental LSA (E-LSA) when they are no longer used for commercial purposes or when the owner wants to change the engine, wheels, or prop to something not approved by the original manufacturer. This new source of experimental aircraft for sport use is the hidden gem inside the world of LSA. 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.

The amateur-built Challenger provides low-cost sport flying fun.

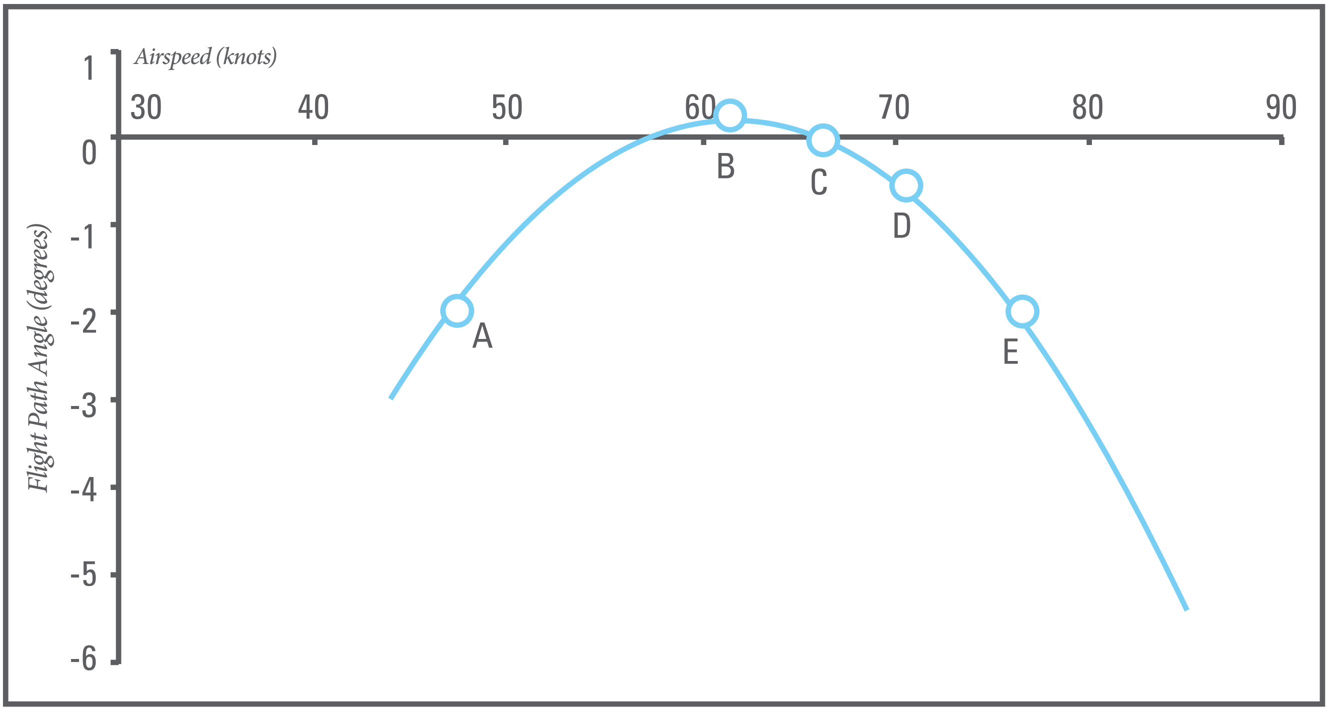


Figure 1

Flight Path Stability

By Ed Kolano

Stability is one of those aviation terms you hear all the time. I've seen it applied to everything from control feel to electronic displays. And so it is with this month's topic, flight path stability, because it's not really about stability in the aviation sense. It's about what changing your airspeed on final approach can do to your flight path angle.

Let's assume for now that your power is constant during your final approach. Not entirely unreasonable, since that's the situation we all strive for, and it's the situation we're stuck with following an engine failure. Now we can explore how changing only airspeed affects vertical flight path.

The Curve

You're on glideslope at the recommended final approach speed with the power set. Point E in Figure 1 depicts this condition. In this example, Point E represents a 75-knot approach speed along a 2-degree glide path. Without changing the power, if you pull the stick back a bit and fly slightly slower than 75 knots, your flight path angle becomes shallower. If you fly, say, 70 knots, your flight path angle would be about ½ degree below horizontal flight, as depicted by Point D. At 66 knots (Point C), you'd be flying level. Slow to Point B, and you'd be in a slight climb in our example airplane.

So far your plane is behaving as you probably expect because it's been flying on the front side of the flight path stability curve, where all airspeeds are faster than the airspeed for the curve's peak at Point B. When operating on the front side of the flight path stability curve, you pull the stick back to fly slower and shallow your flight path, and push the stick forward to fly faster and steepen your flight path.

Airspeeds to the left of Point B are on the back side of the curve, where the slower you fly the steeper your descent angle or flight path will be, unless you add power. Here's why. Suppose you establish your airplane on final approach at Point A, about 47 knots. Notice that your flight path angle is the same as if you were flying at Point E, or 75 knots. Remember, the power setting is unchanged, and all the points in Figure 1 represent a single power setting. If you're not aware that you're flying on the back side at Point A, and you want to make your flight path angle shallower, you might pull the stick back and slow down a few knots. Initially, your flight path would become shallower because you'd be trading airspeed for altitude.

This result is only a balloon effect. With the increased lift comes increased induced drag. As your airplane stabilizes at its new, slower airspeed with no change in power, the increased drag results in a steeper descent angle than you had at the Point A airspeed. This is the insidious nature of the back side.

At this point you have two options for achieving a shallower flight path angle: You can lower the nose and accept a temporarily steeper descent angle (same balloon effect in reverse) until the speed increases above the Point A value. At your new, faster airspeed, the descent angle is shallower. One problem with this nose-lowering option is that it goes against pilot intuition, especially on final approach, where you don't have a lot of altitude to trade for airspeed. That leaves your only other option—add power. Either way, completing the approach after wandering the back side of the stability curve would be a salvage effort, and a go-around is probably the best idea at this point.

Returning to our constant power assumption, we made it so we could see how changing one variable—airspeed—affects the vertical flight path. Increasing power would shift the entire flight path stability curve in Figure 1 upward. Every speed slower than Point B would still be on the back side and every speed faster would still be on the front side, but the corresponding descent angles would all be shallower. Add enough power and you might even climb at the Point A airspeed.

Reducing power shifts the curve downward. Pull enough power, and Point B would be a descent, just like it would be in an engine-out situation. In short, power changes move the curve up or down, but they don't significantly affect the curve's shape.

The Shape

Different airplanes have different flight path stability curves. Figure 2 shows the curves for two airplanes, both of which have a 75-knot final approach speed. If the pilots of these airplanes pushed their respective sticks forward to establish an 83-knot approach

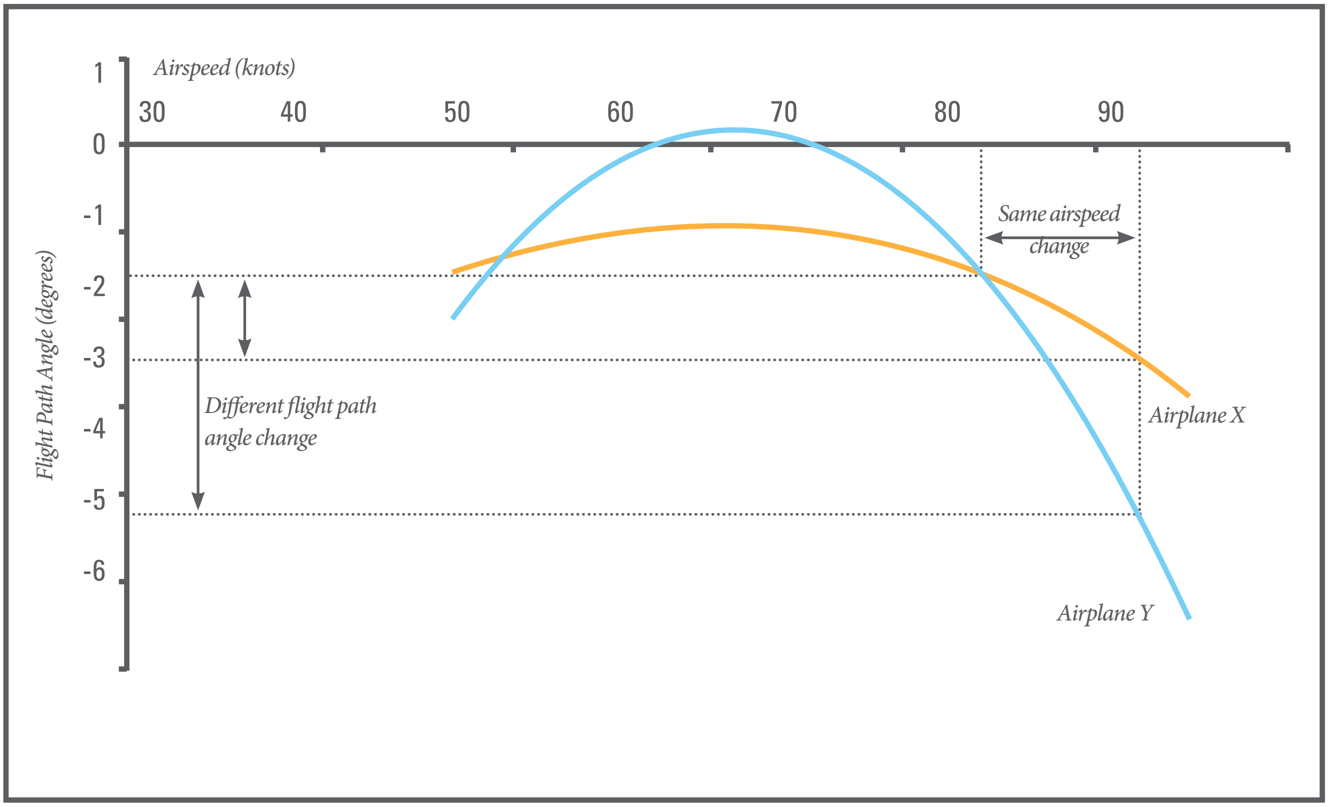


Figure 2

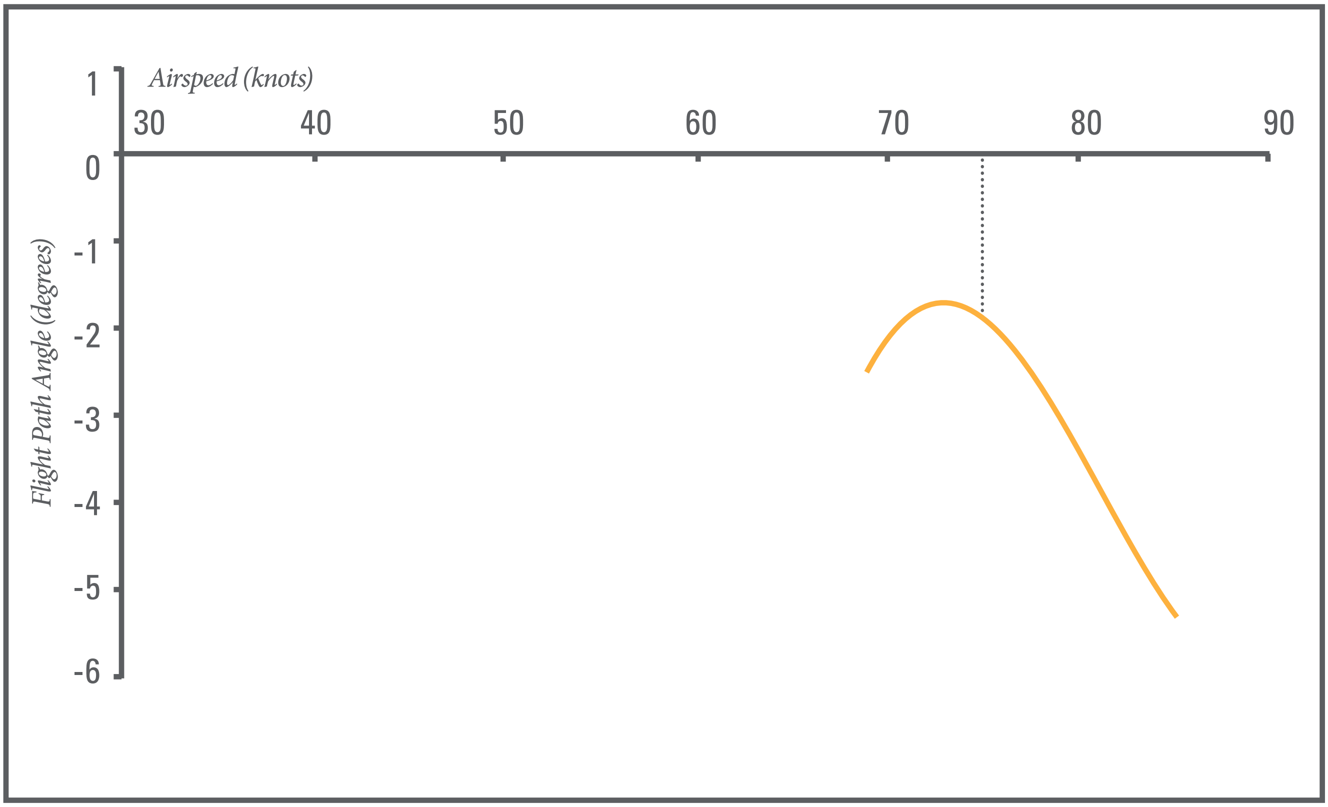


Figure 3

speed, they'd realize markedly different changes in flight path angle.

Airspeed deviations in Airplane Y result in large changes in descent angle, making airspeed control a significantly more critical task than in Airplane X. Because small airspeed variations in Airplane Y result in comparatively large flight path changes, its pilot must diligently control airspeed to remain on the desired glideslope. On the other hand, pilot Y can make minor, short-term glideslope corrections using just the stick and not have to adjust, and then reset, the throttle.

Airplane X's descent angle is not as sensitive to airspeed variations, and to make an effective flight path correction its pilot would have to deviate a lot further from the proper approach speed. The flatness of Airplane X's curve can lead to sloppy airspeed control because the pilot can maintain a near-proper glideslope over a range of airspeeds.

If pilot X doesn't notice—and correct—an airspeed deviation, he will likely see one of two outcomes. Airplane X may land hard because it doesn't have enough airspeed left for a proper flare. Or it will float down the runway in the flare, dissipating its excess airspeed. In Airplane X, you'd most likely make flight path corrections by adjusting power rather than by changing airspeed.

The reality is most pilots don't fly one-handed approaches. We manipulate the throttle and the stick to control the vertical flight path. Flight path stability curves provide an indication of how much of each you'll have to use to make glideslope adjustments.

The Dark Side

Figure 3 shows the flight path stability curve for another airplane with a 75-knot approach speed. Notice how sharply Figure 3's descent angle increases as the airspeed drops below about 70 knots. Trying to stretch a glide in this airplane can result in the bottom falling out too close to the ground to recover, even with power.

There's another insidious deception with some airplanes. Unless you're flying an instrument approach, you won't have a vertical flight path angle indicator. You'll have airspeed and vertical speed indicators, and you do the math to establish the desired descent angle.

Some final approaches give you approximate glideslope indications through VASI and PAPI systems, but at many VFR airports pilots must visually assess their descent angle. We do this by mentally combining the picture through the windscreen with our flight instruments, but this information can be deceptive.

Figure 4 is a composite plot that shows flight path and descent rate versus airspeed. Notice that slowing from 62 knots to 55 knots results in a slower descent rate but a steeper descent angle. This apparent contradiction occurs because the change in true airspeed has a bigger effect on the flight path than it does on the descent rate. You'd be coming down slower, but you'd also be traveling forward slower. It will take longer to come down, but you won't travel as far as you would have at the faster speed.

Let's take this scenario into the cockpit to see why it's an insidious deception. You're established on short final at 65 knots, but you see that you're not going to reach the runway. In an effort to stretch your glide you nudge the stick back just a bit. As the plane's nose comes up, there's a reassuring balloon effect.

Even after the balloon, the vertical speed indicator needle settles onto a smaller decent rate as you continue flying at 55 knots. From the information available to you in the cockpit it looks like you've solved the problem. What you can't see is that your actions have steepened

In an effort to stretch your glide you nudge the stick back just a bit. As the plane's nose comes up, there's a reassuring balloon effect.

the airplane's flight path angle by 1/2 degree. Remember your instructor's mantra: *You can't stretch a glide?*

It's the flight path angle that determines whether you'll reach the runway or clear the trees into that forced-landing field. Unless your airplane has a descent angle indicator, you need to understand your airplane's descent angle sensitivity to airspeed changes; in other words, its flight path stability characteristics.

This month we introduced the flight path stability concept, compared different flight path stability characteristics, played a couple of what-if games, showed how different flight path stability characteristics determine your safety margins, and how your plane's flight path stability can affect the way you fly. Next month we'll present the flight testing techniques and follow that up with the data reduction that will enable you to create flight path stability curves for your airplane. EAA

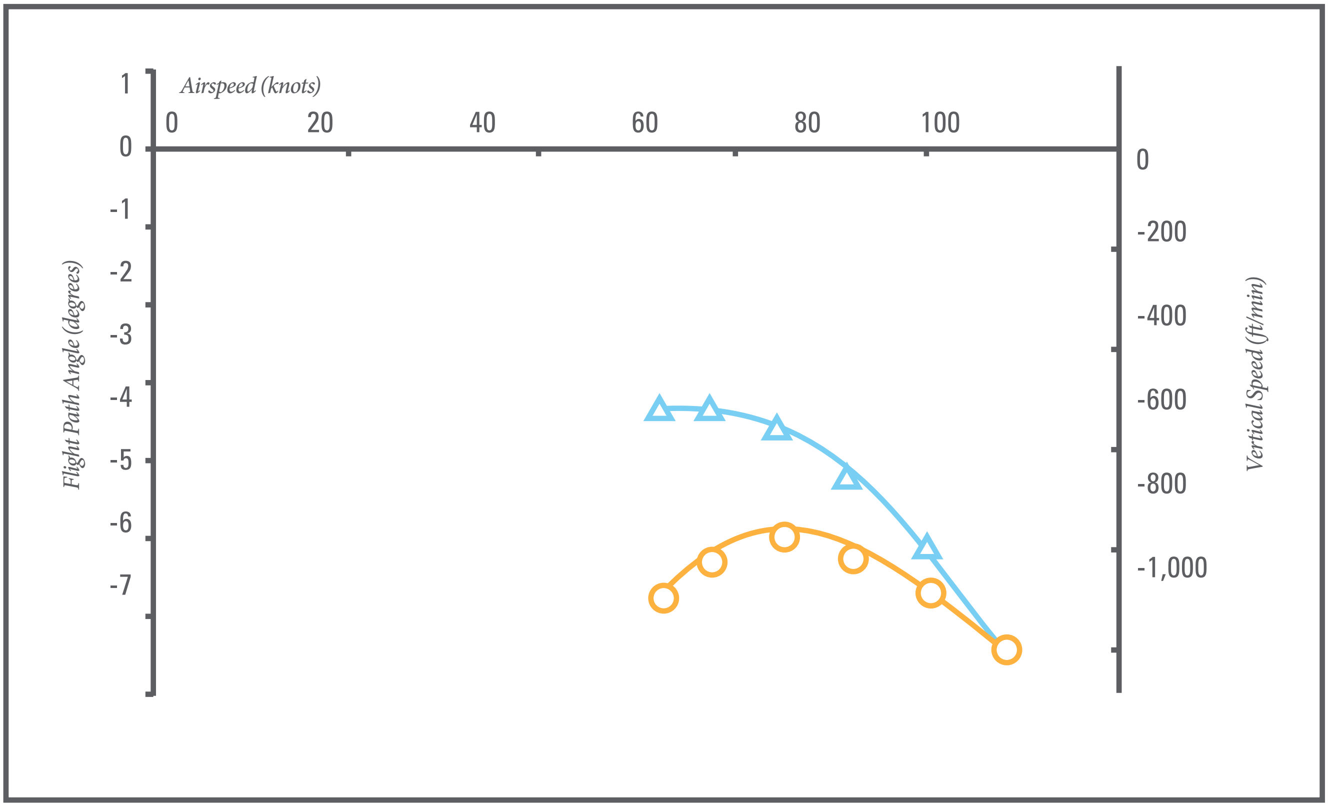


Figure 4

EAA member Ed Zaleski measures the fuel flow in the level-flight position of a Jabiru-powered Texas Sport Cub. A 2-quart measuring cup works well for this.

Fuel System Testing

By Dave Prizio

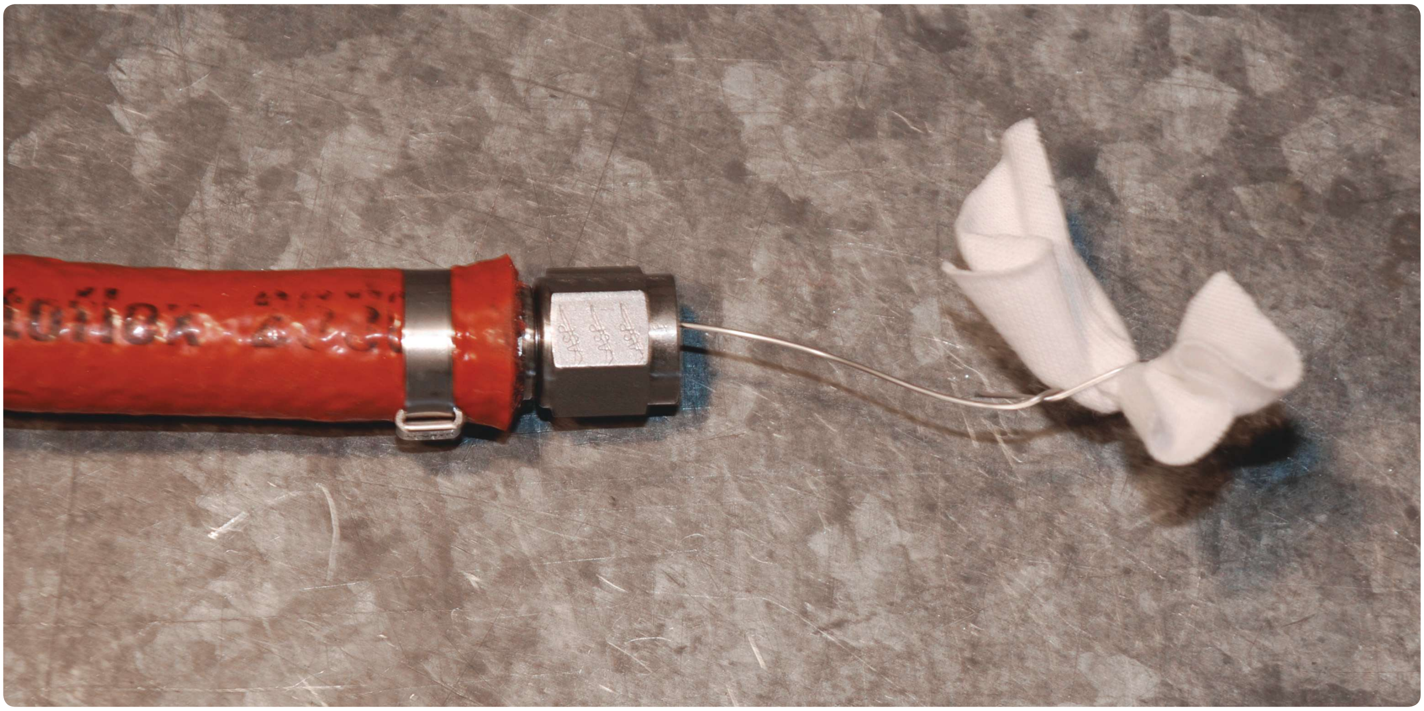
The National Transportation Safety Board (NTSB) recently released a report on its study of experimental airplane accidents. A copy of that report, *The Safety of Experimental Amateur-Built Aircraft*, can be viewed here. It noted a significantly higher accident rate for experimental versus certificated aircraft. Although many of their concerns related more to training than to the construction and functioning of the aircraft involved, the report did zero in on fuel system problems, especially during first flights and Phase 1 flight testing. Based on its findings, the NTSB recommended adding new regulations to the experimental amateur-built (E-AB) airworthiness certificate process, including mandatory fuel system testing.

The EAA and its Homebuilt Aircraft Council do not agree with the need for added regulations, but we do agree that more emphasis needs to be made on proper fuel system testing prior to first flight and prior to flight after any fuel system modification. However, our approach to the problem is to create and promote a voluntary program to address this concern. With a strong voluntary effort, we can get the results we need without adding burdensome regulations.

We agree with the NTSB that fuel system problems can cause serious, even fatal, accidents, and we agree that we need to do what we can to reduce these preventable accidents. Fuel system testing before first flight and after fuel system modifications can save lives. We understand that this testing is difficult and time-consuming, but it is also necessary. Voluntary compliance will save lives and save us from more rules.

Let's look at the kind of testing that is really needed to ensure that your fuel system is truly airworthy:

1. We need to make sure we have adequate fuel flow in level flight at maximum power.
2. We need to be sure that we can maintain that fuel



After making up a fuel line, pull a clean patch of cloth through the line to make sure there is no debris left inside. A gun-cleaning patch works well for this.

flow when the aircraft is in its maximum nose-up attitude. This would be on the edge of a power-on stall in the takeoff configuration—what is often called a departure stall.

3. We need to be sure that even when fuel levels are low that we can maintain fuel flow in the maximum normal nose-down attitude. This would be in a full-flap, power-off descent at the top of the white arc, or in a plane with no flaps, a power-off descent at the top of the green arc.
4. We need to be sure fuel flow remains steady in a slip with low fuel.

All of these are normal flight attitudes. We do not address aerobatic maneuvers in this testing.

Fuel Flow Standards

There are two basic standards that may apply to any particular aircraft. If your aircraft has a gravity fuel system, then that fuel system needs to provide 150 percent of maximum fuel flow in these tests. Gravity systems use either no fuel pump or a fuel pump that must rely on gravity as the backup if that pump fails. Typically these are high-wing aircraft, but some low-wing airplanes, such as the Sonex, also have gravity systems. These aircraft have carburetors rather than fuel injection systems.

If your airplane is fuel injected, and/or if it is a typical low-wing design such as the popular RV models, you need an engine-driven fuel pump and a backup or auxiliary fuel pump, even if you don't have fuel injection. These are called pressure systems, and they must flow at least 125 percent of maximum fuel flow in these tests.

If we need to see 125 or 150 percent of maximum fuel flow, we must first determine what maximum fuel flow is for your aircraft. The manufacturer of your engine may give you maximum fuel flow at full power, or it may give you horsepower and specific fuel consumption (also called brake-specific fuel consumption or simply BSFC). Lycoming, for example, lists BSFC for each engine in a series of publications it calls "Detailed Engine Specifications," which is available from its publications department for each major engine type.

If you can't easily find the BSFC for your engine, you can simply use the conservative figure of 0.55. For you engineering types, the units on this number are pounds per horsepower-hour. The fuel flow for any particular engine is simply horsepower x BSFC. This gives you pounds (not gallons) per hour. This needs to be converted to ounces per minute so we can easily measure it.

Here is a sample calculation:

The Lycoming O-320-D1A engine produces 160 hp. It has a BSFC of 0.51 pounds/hp-hour. We simply multiply 160 by 0.51 to get 81.6 pounds per hour, our maximum fuel flow at full power. We then divide pounds by 6 to get gallons per hour of 13.6. Next we multiply by the fuel system factor of 125 percent or 150 percent and get 17 or 20 gallons/hour, depending on the type of fuel system we have. Continuing on, we divide gallons per hour by 60 to get gallons per minute and then multiply by 128 to get ounces per minute. We then get results of 43 or 36 ounces per minute, depending on the fuel system we have.

All of this can be simplified with either of these formulas:

Gravity system: Hp x BSFC x 1.5 x .36 = Ounces/minute, or

Pressure system: Hp x BSFC x 1.25 x .36 = Ounces/minute

The Tests

To perform these tests we need a few things:

1. a gas can in which the fuel quantity is visible
2. a level, preferably a Smart level (easier to measure angles)
3. blocks or other supports and wheel chocks
4. a two-quart measuring cup
5. a timer or watch with a second hand
6. some willing helpers to position the plane for the measurements.

The first test is the *maximum-power-in-level-flight test*. For this we first level the aircraft both side-to-side and front-to-back. Then place one gallon of fuel in each tank. Be sure to shut the fuel valve off. Next, disconnect the fuel line where it goes into the carburetor or fuel injection servo. If you need to extend the fuel line a bit to make it so you can easily drain into the cup measure, be sure to keep the exit end at the same level as the point where you disconnected it.

Open the fuel valve to verify you have fuel flow. Turn on the auxiliary fuel pump if you have a pressure system. Be sure to catch the fuel flowing out of the line, and have a fire extinguisher handy in case of an accident. If no fuel flows when you open the valve and/or turn on the pump, then you will need to add another gallon to each tank and try again until fuel begins to flow. With fuel flow established, open the valve for one minute and see how much fuel you collect. Then let fuel flow out of the line until no more comes out. Measure this fuel and subtract it from what you put in the tanks to determine your unusable fuel. Compare the fuel drained in one minute to the number you calculated previously. As long as it is equal to this number or more, you are in good shape.

Do not run the engine during this test! Record the results of this test in your builder's log.

With the level-flight test complete, we move on to a more difficult test, the *climbing-flight test*. For this test we will need to put the aircraft in a nose-up position to simulate a maximum climb. We first need to determine the required angle. Here are some possible ways to do that: Consult with the kit or plans designer or measure the angle in a similar aircraft using a Smart level. You will then need to add 5 degrees to that number for your test. If you can't determine the number, you can use 25 degrees for your test and later verify that angle in Phase I flight testing. You don't need to add 5 degrees to the 25-degree number.

With the angle established, position the aircraft at that angle by some combination of raising the nose and/or lowering the tail. You definitely need some help to do this

A kinked or partially collapsed fuel line, such as the one shown here, will drastically reduce fuel flow.

To do the fuel flow tests you will need a gas can, a 2-quart measuring cup, a Smart level, and some cinder blocks or other blocking material.

safely. Use a hole, ditch, or whatever you can find to lower the tail as much as you can. The rest you can do by blocking up the mains.

Be careful! Get plenty of help!

Repeat the fuel flow test as before. Do not run the engine during this test. Record the results in your builder's log. Note that your unusable fuel quantity may be more in this configuration.

The *maximum-descent test* is similar to the previous tests but with the nose down. Again, you need to determine the down angle, which should be the angle in a full-flaps, power-off descent at the top of the white arc (V_{fe}), or if no flaps, a power-off descent at the top of the green arc (V_{no}).

As before, consult the designer for this angle, or measure the angle in a similar plane, or assume 10 degrees and verify it later in flight testing. You do not need to add an extra 5 degrees for this test.

As before, carefully position the plane at the proper down angle. Take care to avoid damage to the aircraft or injury to people. Conduct the fuel flow test as before. A fuel flow of 25 percent of maximum is sufficient for this test since we are testing a power-off descent.

Do not run the engine during this test. Record the results in your builder's log.

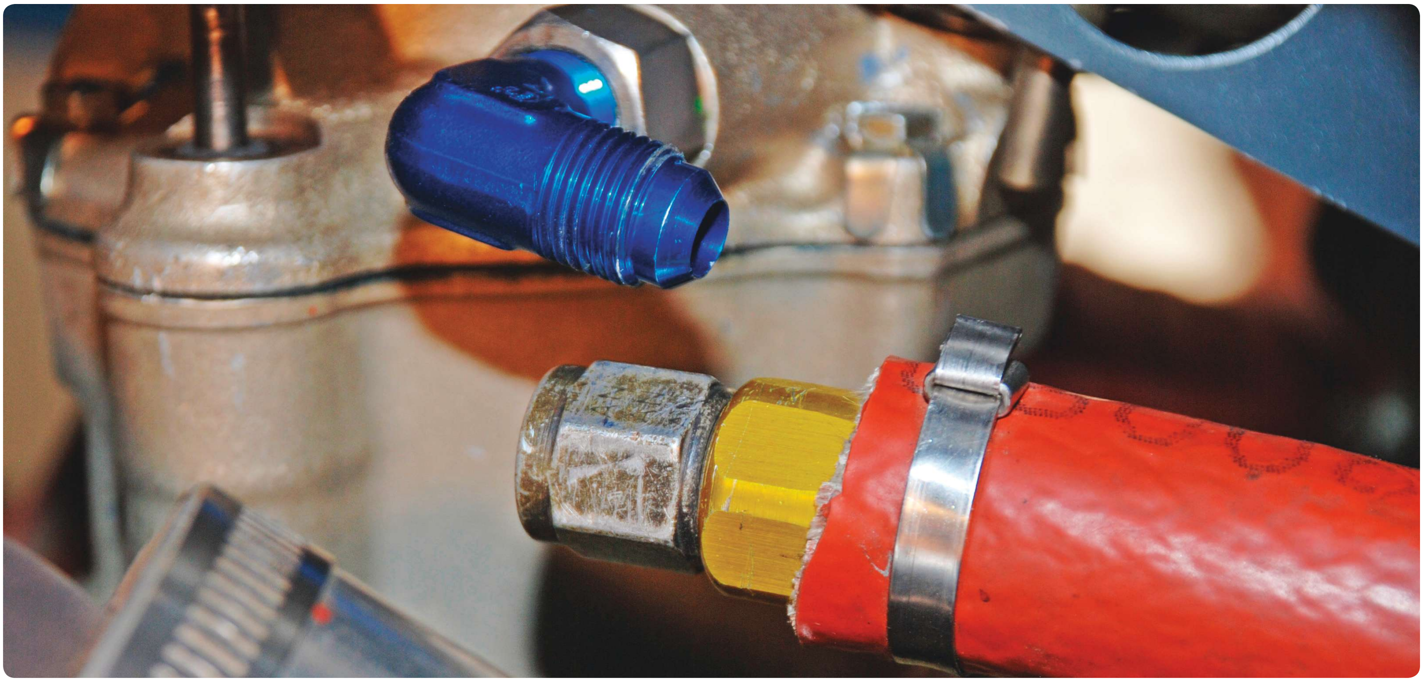
The *maximum slip test* cannot be conducted on the ground; it must be done in flight. While flying over an airport at a safe altitude, burn off fuel until the fuel remaining equals the amount of fuel needed to sustain 75 percent power for 45 minutes. Then place the aircraft in a landing configuration and slow to 1.3 V_{so}.

Consult with the airplane designer regarding any limitations on slipping with flaps extended!

Perform a *maximum-rudder-deflection slip* to the right and hold for 30 seconds. Then repeat to the left. During this test no loss of fuel pressure or engine power should occur. If it does, land safely, add fuel, and repeat the test until a minimum safe amount of fuel can be determined. Record results in your builder's log.

It is our hope that the manufacturers of aircraft kits will perform these tests for you and make the results available to their customers. If you then install your fuel system exactly as per the kit manufacturer's recommendations in every detail, you could then dispense with all of the tests except the level-flight test. Exactly the same means even to the fuel flow sensor and the venting system, especially the venting system. If you delete any of these tests, you should note the reason why in your builder's log, citing manufacturer's testing where appropriate.

Until this information is available you will need to do all of these tests before first flight and after any fuel system



Disconnect the fuel line at the carburetor or fuel injection servo for the fuel flow tests.

A sweeping bend will flow better than a fitting, and a 45-degree fitting will flow better than a 90-degree fitting. Where possible, use the configuration that has the best flow.

modification. Even with the manufacturer's test information, if you make any deviations to its fuel system design, you will need to do the complete regimen of testing.

It is a lot to ask, but your life may depend on it. What a shame it would be to end up destroying the aircraft you worked so long and hard to build, or worse, for lack of a few crucial tests.

If your fuel system doesn't perform up to snuff, here are some things you can look at:

1. Make sure all fuel lines and vent lines are free of kinks and dents. Replace them if they are damaged in any way.
2. Eliminate as many turns, bends, fittings, and valves as possible. Less is more in this case.
3. Use sweeping bends in place of angle fittings where you can.
4. Use 45-degree fittings instead of 90-degree fittings if you can.
5. Simplify your fuel system by eliminating extra filters, check valves, shutoff valves, and other fittings wherever it can be done safely.
6. Check all fuel lines for obstructions, especially flexible hoses. This is best done during construction.
7. Fuel flow sensors can restrict fuel flow. Get one that has the least amount of restriction possible.
8. Do not ignore the vent system. Many fuel flow problems can be traced back to improperly designed or installed vent systems. Stick to the manufacturer's plans or copy a system that is proven to be reliable.

Be safe at all times. Get plenty of help when positioning your aircraft in a nose-up or nose-down configuration. Use solid supports and chock your wheels. Take your time to be sure everything is safe and solid. Do not run the engine during these tests. It is unnecessary and needlessly dangerous. All flight testing should be done at a safe altitude and location such that you can easily make a safe landing in case of an emergency.

We know these tests are cumbersome and frankly a pain in the rear end, but nothing like the pain you will experience if you crack up your new airplane. Engine failures can kill you. If we don't step up and do our part, the FAA will come in and tell us what to do and how to do it. That will make it more difficult to build an airplane and less fun. No one wants that.

Do these tests before your first flight and after any fuel system modification, and encourage your friends to do the same. Be safe and promote safety. 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.