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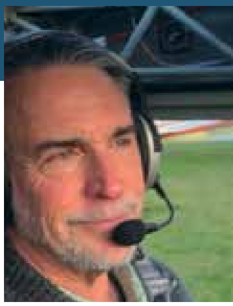
On the cover: Steve Henry's heavily modified Just Highlander, *Yee Haw 7,* is a top performer in the STOL Drag racing world. Photographed by Leonardo Correa Luna.



EDITOR'S LOG

A Hole Where an Airshow Should Be

EAA's decision to cancel AirVenture 2020 as a precaution against the coronavirus has created a tremendous ripple effect. Not only are your travel and leisure plans for the summer likely to have been upended, but it's impacted the way manufacturers and suppliers reach their intended audience. With few exceptions, aviation—especially our corner of it—is pretty old school when it comes to outreach methods. Manufacturers like to have face-to-face contact to answer questions. Especially where aircraft kits are concerned, there's the none-too-subtle art of showing off your design while simultaneously and skillfully revealing to the potential customer that you're the real deal—a company whose principals are steady, honest, engaged and the kind you want to have a relationship with as your build progresses. That's hard to do in a press release or YouTube video, though it's certainly been tried.

We love AirVenture not just for the opportunity to visit with friends and reimmerse in the world of homebuilt aircraft, but also because there's usually a concentrated dose of "stuff going on." New products, industry changes and updates, legal and regulatory issues announced during various fora—all things that keep us on the show grounds from dawn to dusk. We mine this deep vein of content for quick-turnaround stories for our website, it's true, but you may not appreciate how much planning and idea-seeding happens at Oshkosh. We work our tails off for a week but feed for months on those stories, leads on projects and builders and, yes, the airplanes we've flown.

What does that mean for our coverage? For one, we'll continue to hound—er, *strongly request*—information from across the industry. I write this a full month before AirVenture was supposed to begin and know from experience that a lot of companies are still finalizing their announcements at this point. Many, I suspect, are still hammering out details on the flight to AirVenture every year. I'm also aware of a few companies that have taken cancellation of both Sun 'n Fun and AirVenture as an opportunity to revise product timelines. Many companies across the spectrum—engines, airframes, avionics—have as one of their development hard points the release at one of the big airshows. Without that, I suspect we'll see a more gradual, one could almost say organic rollout of new products and services over the course of the summer and fall. Of course, there are still significant economic and cultural issues in flux; it's typical for some of the smaller businesses to ease up on the development accelerator in conditions like this.

The Virtual Booth

What I have heard over the course of my conversations this month is the willingness for companies to do more virtually, and some are pushing fairly hard to replace the "airshow experience" for customers. EAA, for its part, has been very successful with its webinars over the spring and the calendar only looks to expand the offerings over the summer. Its efforts to "replace" AirVenture will hinge on its Spirit of Aviation week (July 21-25), which will feature streaming presentations and forums, workshops and a "virtual exhibit space" with products and show specials. Garmin will have its own version of product tutorials presented virtually, and I know that Dynon will fill out the product tutorials and

Marc Cook

Marc Cook is KITPLANES' Editor in Chief once again, after a hiatus playing with motorcycles and learning about e-commerce. A veteran special-interest journalist, Marc has built two airplanes, an Aero Designs Pulsar XP and a Glasair Aviation Sportsman, and now owns a 150-hp, almost-as-simple-as-it-gets GlaStar based in Oregon. Marc has 4500 hours spread over 200-plus types and three decades of flying.

open discussions it has held through its Facebook page. You can expect to see more programs like Zenith's virtual builder workshop (see Kate O'Connor's feature on Page 40) emerge through the year; I strongly suspect that if these are helpful to customers and moderately successful, they'll continue in some form in our post-COVID world.

Of course, we'll continue to follow all of these developments and report on them first at *www.kitplanes.com* and then showcase them here in the magazine. We're also looking to expand on our Virtual Oshkosh section (see Page 5) that gives companies another way to reach you. And, finally, we're going to keep on with our video efforts to check in with companies and builders, as well as share updates on the products we're testing and projects we're working on.

We Must Be Nuts

Here's a sampling of the reader feedback I thought you'd enjoy. This is from Raymond Henrie, who writes: "I was flipping through the July issue and Paul Dye's article on rivnuts grabbed my attention. Unlike Paul, I *love* them! I have used them on all kinds of projects, including the two planes I have built. I'd like to add just a little useful information. First, I have found the ribbed rivnuts at a reasonable price on eBay, probably military surplus. Second, I prefer JB Weld as reinforcement to prevent turning because it has a thicker consistency, which I believe makes a stronger bond. Third, I *hate* nutplates because they have an interference fit to prevent loosing that also causes many stripped screws. I use a small rubber O-ring under the head as a kind of lock washer, and I have never had one come loose. I really love the homebuilding tips." I'll second the recommendation for "ribbed" rivnuts. I've used the "twist-resistant" rivet nuts sold by McMaster-Carr, both steel and aluminum, depending on the application, and have had very few problems. They're comparably priced to aviation nutplates and can be installed quickly with the correct tool, though, like anything, proper technique makes all the difference.

Larry Flesner's light, fast KR. Very much a composite airplane.

Wooden It Be Nice?

The next missive comes from Larry Flesner, who points out an error when we said the KR2S was "originally an all-wood design." "The fact that Ken Rand and Stu Robinson designed the first homebuilt to use wood-composite construction seems to be, unfortunately, lost to history," he says. "The original KR1 was built using a wood fuselage, wood spars and composite-over-foam wings and tail surfaces. The KR2 followed and then, with builder input, the KR2S. Very few KRs are built the same due to builder changes but they remain, in my opinion, the best bang for the buck speed, ease of

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building and fun to fly homebuilts on the market today. I may be a bit biased, having 700+ hours in my stretched KR with an O-200 and having hosted a dozen or more annual KR Gatherings. But any honest exposure to the KR design would validate my opinion." I appreciate the correction, Larry.

And This Bearhawk Makes 5

One new airplane design we were really hoping to see up close at AirVenture is the new Bearhawk Model 5. I had a chance to talk to Bearhawk's Mark Goldberg via Zoom (see the video at *www.kitplanes.com/video*) and he elaborated on the design choices and filled me in on the development timeline. In fact, how it came to be is a story by itself—basically it was created by Bearhawk designer Bob Barrows for a fellow builder, "a big guy," who started the project but could not finish because of health issues. Enter Collin Campbell, multi-Bearhawk builder, who took on the project and saw it to completion earlier this year.

Bob Barrows is a clever guy when it comes to design, so the Model 5 keeps most of the familiar four-place Bearhawk technologies and philosophies. "It doesn't differ in a lot of ways from the current production Model 4, but it's wider and longer," Goldberg told me. "The shock struts are set up differently...and the other difference is that it's designed to accept one of the heavier angle-valve [Lycoming] 540 engines." Even better, the prototype has a custom IO-580 engine on the same platform with 315 hp. Beyond that, "it's really incremental improvements, not a whole lot of difference in the way they go together," says Goldberg. The all-metal wing is the same as on the current four-place model, for example, and the basic design of the tube-and-fabric fuselage follows the basic concepts of the four-seater, though the fuselage cage will obviously be different and there are changes to the tail surfaces as well.

Similar to the four-place, sure, just bigger. Overall, the Model 5 is 24 inches longer than the four-place, much of that going into the cabin. Goldberg says that the interior volume is greater than a Cessna 185's—though that doesn't mean it's the same shape—and if the airplane is built light, it should have a useful load of nearly 1500 pounds. (Maximum gross is expected to be 3000 pounds.) Predicted cruise speeds are in the 160-mph range with the IO-580, and while that's not blazing fast, the Bearhawk is more about getting into and out of short strips and climbing well in high-density-altitude situations, which it most definitely should do with the promised power loading of less than 10 pounds per horsepower. Incidentally, the Model 5 can accept any of the six-cylinder Lycomings, though it's expected most builders will go for the angle-valve engines of around 300 hp.

As I write this, the sole Model 5 is continuing its Phase I flight testing, with a lot of work validating the weight-and-balance envelope and verifying flying qualities heavily loaded still to come. Goldberg told me that even with a sodden turf strip, the Model 5 was having no trouble getting out of a short runway. Bearhawk is also expected to test different tire sizes for the Model 5, since the lengthened fuselage actually decreases the resting angle of attack and makes full-stall landings more difficult.

Of course, with just the one airplane flying, much remains to be done to get kits and plans out the door. According to Goldberg, "Our hope is to have all the tooling done by the first of July, and then I'll send down the materials for the first production run of kits. And we hope to have the first kits in October. Which is what I already promised the two guys who have sent me deposits for kits."

Bearhawk has components assembled in Mexico, including the Model 5's quickbuild wings that carry over from the Model 4. Kit prices have not been finalized, but a full quickbuild version of the Model 4 runs $47,000, which includes all the metalwork but not the covering system, which is of the builder's choice. It also doesn't include the windshield (a common Cessna part), wheels and brakes, cables, pulleys and hardware. Obviously, the engine, avionics and prop are extra, too.

You can bet we'll keep track of this project and one of us will pay Campbell and company a visit a soon as we can.

The new Bearhawk 5 (above) and builder Collin Campbell (right).

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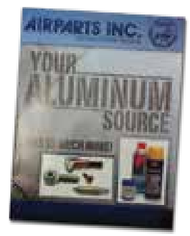

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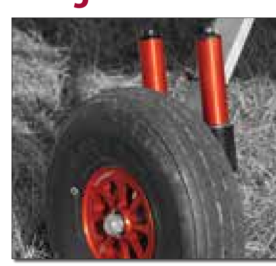

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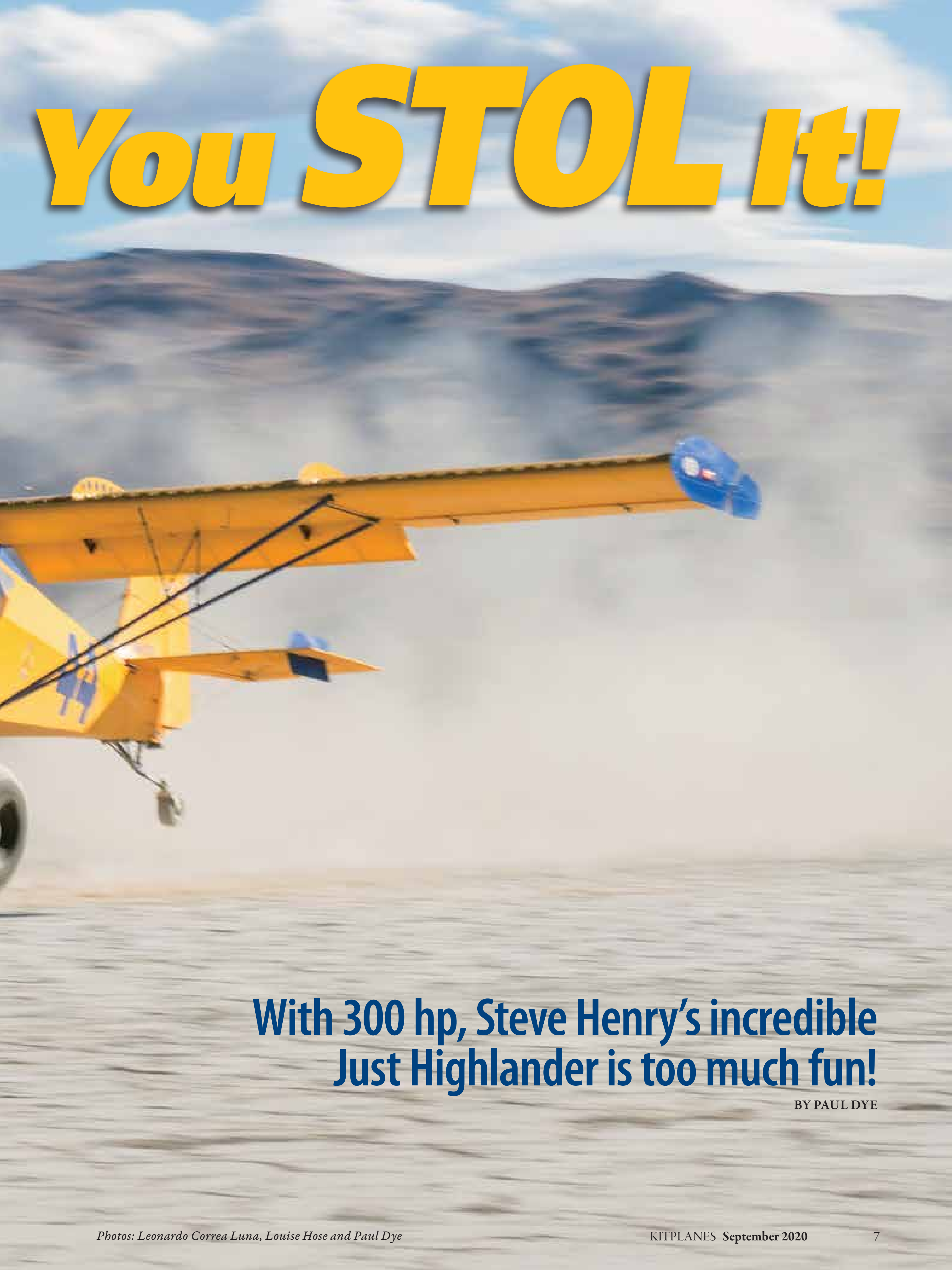


You STOL It!

With 300 hp, Steve Henry's incredible Just Highlander is too much fun!

BY PAUL DYE

Photos: Leonardo Correa Luna, Louise Hose and Paul Dye

Steve Henry is a man who likes to get his airplane off the ground in a hurry. A *big* hurry. We taxied out on the 5000-foot runway and lined up with a slight tailwind to avoid staring directly into the setting sun. He held the brakes and added a touch of throttle to lift the tail off the ground. Then he advanced the throttle on the 300-hp turbocharged Yamaha until it was clear the brakes and tires had had enough and weren't going to stay glued to the pavement anymore. At that point he released the brakes, added full power, and we shot off the line like we'd been fired from a cannon! Before I could count to two, we were off the ground and climbing away at a phenomenal rate. As we passed the end of the runway, well above pattern altitude, Steve turned to me, smiled and said, "Next time around, I'll show you a maximum-performance takeoff."

I am still trying to wipe the grin off my face.

The airframe we were flying was Henry's seventh build, a Just Highlander with more than a few modifications. It was also the LSA Reserve Grand Champion at AirVenture in 2019, an award won not only for workmanship, but for innovation. And innovative the airplane surely is. Oh, by the way, this was Henry's second Reserve Grand Champion in a row—that's two in consecutive years. The man not only has talent, he is consistent. This particular Highlander is far from stock, and we sat down with him to go over some of the mods and innovations that won him the Lindy—and more importantly, that make him a consistent winner in the world of STOL competition.

Steve Henry, creator of *Yee Haw 7*—and the six *Yee Haws* that came before it!

We got a chance to fly with him in the high desert just east of Carson City, Nevada, where he stopped on his way to the High Sierra Fly-in held in October each year. The High Sierra is a chance for backcountry pilots to get together on a dry lakebed north of Reno (you know it's gotta be a great place to fly with a name like "Dead Cow Lakebed") for several days of making dust fly and having fun fooling around with flying machines. Home of the STOL Drag races, the HSF is a rapidly growing event that this year saw over 120 pilots trying to qualify to compete in the drag competition itself—that's a lot of airplanes looking to fly fast by going slow.

Steve Henry has been winning STOL competitions as well as the STOL drags with significant regularity, so we

Steve Henry was a Reserve Grand Champion at AirVenture two years in a row and is a consistent winner in the world of STOL competition.

Steve Henry removes the cowl to unveil the EPeX300Ti turbocharged Yamaha engine (left). The three-blade composite, ground-adjustable NR prop (right) does a great job of hooking the engine up to the air.

thought it was time to take a close look at his current machine and see if we couldn't pry some secrets out of him. To our delight, he was more than willing to share—so here we'll share some of the secrets of his success.

But First. . .How Does It Fly?

I've flown most of the representatives in the fast-growing, LSA-qualifying STOL airplane category in the past few years and have gotten used to the long climb over the bush wheels and the "hoisting yourself in" by doing a pull-up on the fuselage tube to settle into a seat from which you can see well out the sides. The Highlander known as *Yee Haw 7* isn't much different in that regard—until you start looking out the multiple windows at the view—even on the ground. No, you still can't see straight ahead, but the modifications Henry has made to the glareshield and boot cowl, plus the addition of the little triangular windows down by your feet, give you a far better view of the world right from the start.

The large three-blade prop you stare at from the seat is a clue that this is going to be a different ride. Appropriately sized for something that starts with "Lyc" and ends with at least "360," it's a ground-adjustable, composite scimitar that is clearly sized to redistribute some significant horsepower. You get a hint of that with the startup—a low rumble that is supplanted by a whirring spool-up sound when the power comes in. Yeah, there's something at the other end of the throttle cable.

An airplane designed for 100 hp is going to be different when you triple that figure, and it was clear right from the start that this machine could do just about anything the pilot asks when it comes to low-speed performance—and that includes getting up off the tailwheel and standing tall with just a small amount of throttle and enough brakes to keep you in place. Henry can basically make the airplane walk through the desert, turning a little here to make the right wheel go around a rock, then a little there to swing the tailwheel over a sagebrush. Control is not a problem when you're doing it with power!

That power, of course, has to be respected, and one of the things Henry mentioned several times is that you can't put a low-time pilot straight into the seat and expect them to safely use the airplane right off the bat. That much power in that light of a kite is a scaled version

Despite the 300-hp engine and tall landing gear, this is still an LSA-sized airframe. Keeping a strong power-to-weight ratio is a great way to add performance.

The panel contains the Vigilus engine monitor from Flybox, a GRT EFIS and a place to mount an iPad—more than adequate for a traveling bush plane.

of the P-51's tendency to torque roll if you go to full throttle without adequate airspeed to give the control surfaces something to bite into. Yes, you could easily wreck this thing if you're careless with that black knob. However, learn to respect it and use the power when the other controls are ready, and you've got an amazing machine.

Due to insurance requirements and a healthy desire to learn by watching (rather than by making a mistake), we sat with hands in our lap while Henry rolled onto the runway, held the brakes and added enough power to get the tail up—which wasn't much. He then added more, and more, and more—and when the brakes had had enough, he let them go, put in more power, and the result was acceleration on a scale I have rarely felt in an airplane, even one with a constant-speed prop! Yup—this thing just goes! And then it goes *up*! With two of us aboard, we probably used about two airplane lengths of the mile-long runway. Our airpark homeowner association board would be happy that we weren't wearing out pavement.

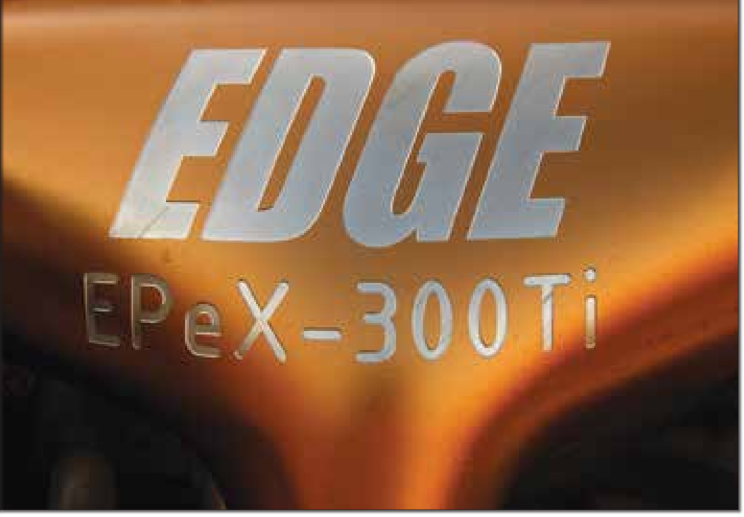
It didn't take long to get up and away from the pattern, where we had only a few minutes before the sun was sinking into the surrounding mountains. This was just a demo sampler, not a full evaluation, but the airplane was well-mannered in turns, held altitude like it was on rails regardless of bank angle, and flew along easily with flaps up at 34 mph. To be honest, I don't trust airspeed indicators to be accurate below about 35 and lump everything in that category as "adequately (or ludicrously) slow."

We descended into the pattern for a couple of landings, and once again, it was clear that we had *way* too much runway for our needs. We landed and stopped the first time in the length of one of the underrun arrows, and Henry wasn't the least bit overworked. He then said "Let me show you what the STOL Drag is all about."

The STOL Drag is a race where you essentially get off the ground, fly about a thousand feet, land, come to a complete stop, turn around, and do it all again in the other direction. You do it side by side with another airplane and see who crosses the finish line first. It's a test of an airplane's ability to get airborne quickly, move through the air fast, and then get down and stopped as short and fast as possible.

Henry once again held the brakes and lifted the tail. The cat shot was even quicker than before, and we were off the ground in a wink. He leveled and shot forward with all 300 horses going to cover the distance, then pulled the power and threw the airplane sideways to slow things to landing speed as quick as he could. The landing was like watching a gymnast stick the dismount. Then he turned it around and was ready to

Can you say "stall fences"? The airplane's wing is all about straight flow when headed straight on and developing drag when slipping.



For a powerful propulsion package, the EPeX300Ti is impressively small, with a simple and clean design.

go again in the opposite direction. But because this was a civilized runway, with a pattern favoring one direction, he instead pirouetted on the mains, and we took off in the direction we'd been going—all way faster than it took for me to write that.

Overall, I took away a far better understanding of what you can do with a low-speed airframe and lots of power. It's a lot like those dreams where you're flying without an airplane, just holding your arms out and moving over the trees, dropping a foot here and there to touch a meadow or tap on someone's rooftop. Yeah—a guy could get used to having one of these machines just for playing around!

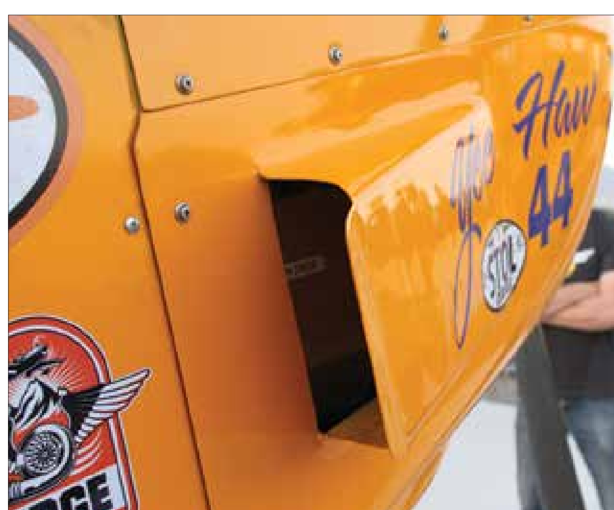
Power, Power, Power!

Henry, when asked about the winning performance of *Yee Haw 7*, admitted that while he has done a lot of little aerodynamic things along with the new wing, the real winning performance is probably due to the 300 hp provided by the EPeX300Ti Yamaha-based engine. Marry 300 hp to a Light Sport Aircraft and what else would you expect?

The motor is the work of Edge Performance, a Norwegian company that is represented in North America by Edge Performance of Lacombe, Alberta. The core engine is a four-cylinder inline Yamaha Apex snowmobile four-stroke, with five valves per cylinder. Edge Performance marries it to a gearbox designed by Teal Jenkins, and a turbocharger, making the 1000cc engine a powerful package in a small (and light) container.

It might surprise the many owners and operators of Lycoming-powered aircraft that such a motor not only exists, but has been flying for a while now in non-turbocharged form. The fact that the Highlander hides the massively powerful motor under what looks to be roughly the same size cowling it uses for a Rotax is impressive. If it weren't for the labeling and signage proclaiming the horsepower, the airplane would be a true sleeper if it pulled up next to you at the start line. With electronic fuel injection and ignition, it is a modern engine that so far is looking to be reliable.

Now we're the first to admit that new engines—especially conversion engines—have a tough job to prove their longevity and reliability in the field. The old, established aviation motors took half a century of use in tens of thousands of airframes before words like "bombproof" started to be applied to the basic engines. So being skeptical is a good thing. But we have to admit that progress is made when people take a step closer to the risk line, and so far the powerplant looks promising.



The turbocharger mounts on the left side of the engine compartment (left). With an engine that produces 300 hp, there is a lot of heat to get rid of, and Henry has added considerable exit area to the cowling to make that happen (right).

Steve Henry travels with his "quiet muffler" installed (left), but admits that it does give away a little potential power. His race muffler (right) is pretty much a straight pipe, and it easily swaps out with the quieter unit.

Of course, horsepower is not free, and the laws of physics have to be obeyed, so with hefty throttle settings come equally hefty fuel flows. Full-throttle gallons-per-hour was reported to be in the mid-20s—but at least it can (and does) burn 91-octane auto gas as easily as 100LL.

When asked for a package price, we of course, received the standard "that depends" on things like actual configuration and options, but $23,000 was mentioned as a ballpark figure.

The Wing

Once you get over gawking at the excessive power production of the motor, you pick your jaw up off the floor and start looking at the airframe. The most obvious change to the basic Highlander design is a brand-new, custom-designed wing. Henry used a Harry Riblett airfoil and the original Highlander spars, but just about everything else came from his own ideas. Most noticeable is the fact that the flap and aileron chords are about a third of the entire wing chord—the surfaces are pretty large, to say the least. The flaps have quite a bit of travel and are controlled from the cockpit through a standard cable system, but the handle uses a hydraulic system to lock and release them in essentially any position, rather than having mechanical detents that limit you to just a few positions.

The wings are conspicuously void of leading edge devices so common on STOL airplanes these days. No slats—either fixed or moving—and no significantly noticeable humps or bumps. They do feature large stall fences on the upper surfaces, however, as well as vortex generators in strategic locations to keep the flow attached and going where Henry wants it.

Henry's goal was to provide better STOL capability without a loss of top-end speed. He said he does like three-digit speeds (in mph) and doesn't want to sacrifice the ability to go cross-country without growing old in the process. He admits that while he did see an improvement in STOLishness, the

Henry designed the wing (left), which includes a generous-sized tip fence to keep the air flowing over the airfoil. The Shock Monster landing gear (right) absorbs just about any touchdown conditions you can throw at it.

gains were minimal, and he might not build his next plane with the same wing design, coming to the conclusion that the Highlander wing is probably just as good a platform to begin with if you're going to add other devices and toys.

You Have to Stick the Landing (Gear)

Flying slow so that you can land short doesn't do you any good if you can't stick the landing. A big bounce not only looks bad, but also adds to landing distance if you have to add power to get things back under control. It might even force a go-around. Henry knew this, and it's why he incorporated gear legs and shocks from Shock Monster, a company based in Lincoln, California, that is rapidly becoming known for its extreme landing gear.

The ideal landing gear is one that can absorb the energy of landing and not put it back into the airplane to lift it back off the runway. In our brief experience flying with Henry, we think the gear that Shock Monster provided for the Highlander does just that. I like to describe it by saying that the landings "just went squish." There was no feeling that a rebound was imminent, but it also didn't feel like the gear was going to collapse. It just worked.

That is the main gear of course—the tail spring on *Yee Haw 7* is stock Highlander, with a long-stroke shock absorber that disappears into the fuselage structure, allowing radical touchdowns with no rebound. The tailwheel is a squared-off, but bulbous, tire on a full-swivel yoke. There was no doubt it worked well in Henry's hands, and it stood up to whatever he needed to do to it.

Always Tinkering

We have to admit that the first thing we noticed as Henry taxied up in the *Yee Haw 7* were a set of clear plastic panels mounted to each set of jury struts. Aligned with the direction of travel, they were filled with holes that looked to be about two inches in diameter. In normal flight they are invisible to the air—but throw the airplane into a sideslip and they looked to the oncoming

Henry uses a small hydraulic system to hold the flap lever in any position he wants (left). The valve quickly dumps the pressure for quick retraction. Henry's latest idea for adding drag in a sideslip: These speed brakes are fixed and only come into play when you cross control to slow down (right).

air molecules like huge speed brakes—just like what you might find on an old WW-II dive-bomber. Part of the challenges of the STOL Drag competition is that not only do you have to go fast (it's a race after all), but you also have to slow down quickly, and anyone that has seen the action knows just how extreme the slips get when it comes time to slow down and land. These drag devices were added just a week before we saw the airplane on its way to the High Sierra Fly-In—yet another attempt to stay on top!

Henry's other additions have been equally well thought out. For instance, the standard Highlander has the elevator push-pull tube mounted on top of the baggage floor. He put his underneath, creating a *huge* flat floor and baggage area that could hold a whole lot of whatever you might want to carry into the backcountry.

From drag devices to lift enhancers—from new windows to cooling ducts and radiators—Henry has continued to add improvements to his designs, and his is a plane to go to if you want ideas for how to improve any area of performance. This is one reason he won his second Silver Lindy at AirVenture 2019—not only for his workmanship, but for his innovation. In our opinion, it was well deserved.

Going Wild

Steve Henry is a soft-spoken, interesting fellow with a lot to say—but he primarily lets his airplanes do the talking. A late-in-life pilot (he didn't start flying until he was in his 40s), he thinks things over carefully and applies common sense to problems to find solutions. Nothing he does is magic—but he's willing to work hard to prove his ideas, and the fact that he is on his seventh airplane is proof that he is constantly coming up with more of those ideas.

Whether it's flying for pure STOL performance at AirVenture, or flying the STOL Drags at Reno or the High Sierra, Henry's airplanes are something to contend with. And we think we'd love to give one a try out of the limelight, just loaded up for a camping trip to some backwoods strip. Or better—no strip required—just find a few hundred feet of clearing and go for it. This airplane is the nearest thing we've seen to a helicopter with fixed wings.

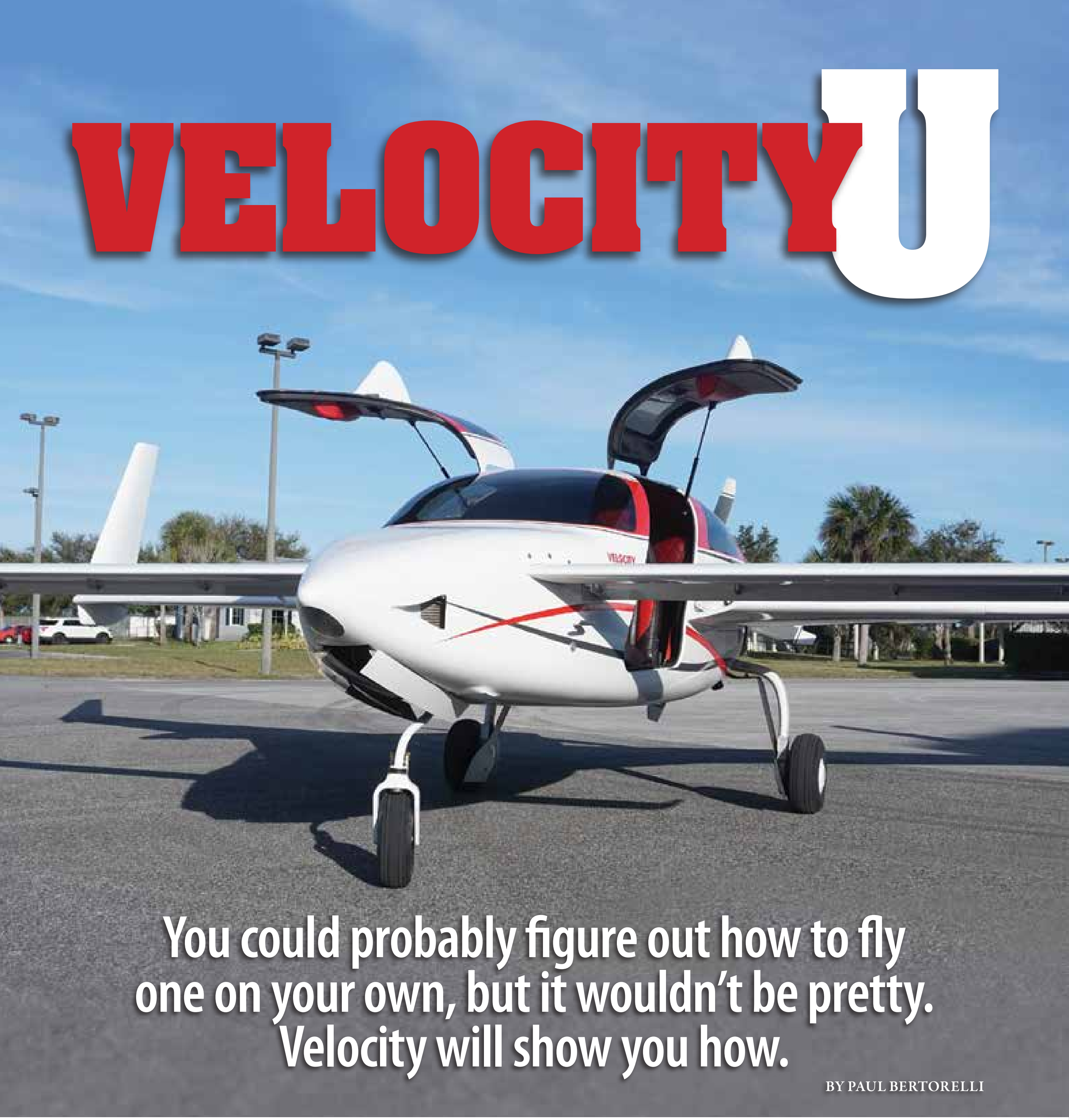
Websites

Steve Henry
www.wildwestaircraft.com

Engine Provider
www.badasspowersports.com

Engine Engineering
www.edgeperformance.no

VELOCITY U



You could probably figure out how to fly one on your own, but it wouldn't be pretty. Velocity will show you how.

BY PAUL BERTORELLI

The ego is a marvelous and durable thing. Affix pilot to the word, however, and it morphs into something larger and potentially indestructible, thus many a builder has attempted first flight of a new airplane rather than letting a pilot expert in the type wring it out first. Hey, to be fair, it usually works out. But sometimes not.

On the theory that training assures a better outcome, Velocity Aircraft—a kit manufacturer with antecedents to the mid-1980s—offers a two-day training program for its line of canard singles and twins. Given that there are about 700 Velocity examples of various ilks flying, the course is aimed not just at builders, but increasingly at buyers who might be purchasing from the original builder or even one that's changed hands a few times over.

But seriously, do you really need to spend money on this, considering how effectively an airplane project can otherwise sop up every dime? To find out, I recently spent a day at Velocity's home base in Sebastian, Florida, reviewing the course. I'll give you the executive summary up front: The answer is yes. On the spectrum of airplane handling characteristics, the Velocity is north of challenging but maybe south of really weird. Training is a good idea.

The History

The reason for that relates to the airplane's developmental history. If you're not familiar or never knew, you'd be forgiven for thinking that the Velocity is a Burt Rutan project. After all, with its prominent canard and swept wing, it looks like a scaled-up Long-EZ. While that's a reasonably accurate description, it's more accurate to say it was Rutan inspired, but he had nothing to do with the project.

In the mid-1980s, a Long-EZ builder named Danny Maher decided what the world really needed was a scaled-up version of the airplane with four seats. Using the expedient of simply lofting the Long-EZ's lines with plumb bob data points and scaling up the dimensions, Maher did exactly that.

"But the main problem with trying to make a larger version of the Long-EZ was the canard," says Velocity CEO Duane Swing, who took over the company from Maher in 1992. "The Long-EZ only had to support a pilot. The rear seat was on the CG so it didn't make a difference on the weight. But the pilot was the main thing. He could be from about 150 pounds to 250," Swing says.

But the Velocity was envisioned as a four-place airplane, with a much wider cabin and two pilots in the front seats. "So now you've got potentially two 250 pounders in the front seat, which really became a big problem," Swing says.

Maher noodled the problem with another Long-EZ builder who was a NASA engineer and after many iterations and wind tunnel trials, they settled on a larger canard with a Fowler flap for the elevator control surface. "It's hinged down low so when it deflects down, it actually extends the chord of the canard.

Velocity owner Duane Swing: A key design challenge was giving the canard enough pitch authority to support two people up front, forward of the CG. The solution was a larger canard with a Fowler flap for an elevator. "So that solved the problem of having two 250 pounders in the front seat of a Velocity."

Velocity offers three kit options: the V-Twin, foreground; the SE, center; and the retractable-gear XL, background. The company keeps an SE in its own stable as a trainer to introduce buyers and builders to the finer points of flying the airplane. Training is done at Velocity's Sebastian, Florida, headquarters.

Photos: Paul Bertorelli

Velocity veteran and CFI Ingrid Meier conducts the two-day training course. Here she puts Paul Bertorelli through the same in-depth review of the aircraft, its systems and characteristics that she gives to owners who are buying rather than building. The second day of the course concentrates on landing and after you've bungled the first one, you'll see why.

"So that solved the problem of lifting two 250 pounders in the front seat of a Velocity," Swing explains.

Were it so simple as that, however. The operative theory of canards is that with the pitch control at the front of the airplane, the flying surface can be set to stall first, so the main wing never reaches stall angle of attack.

But some airplanes, even those with conventional control surfaces, have a deep stall mode, although it may take effort to find it. Essentially, a deep stall is one where there's insufficient pitch authority (or thrust) to get the wing back below the stall angle of attack.

Swing likes to tell the story that in early development, test pilot Carl Pascarell got the airplane into a deep stall from which he couldn't recover. About to bail out, he realized the vertical speed was no faster than his parachute so he rode the airplane down into a splashdown in the Atlantic Ocean off St. Augustine. Being of foam, the airplane floated, so it was towed to shore, repaired and flown again. The pilot was uninjured.

The fix was leading edge cuffs that, in effect, extend the main wing chord and distance the main wing stall angle from the canard stall angle by 4 or 5°, with the canard giving up first. Swing says that change and the use of constant-speed props to provide more thrust has all but eliminated the deep stall risk. But the airplane retains a unique flight characteristic called the pitch buck and that gets us to training.

Two Days

Flight instructor Ingrid Meier, whose regular day job is driving airline 737s, conducts the Velocity school over two days. It costs $1900 and consists of five hours of ground work and five of flying, with a concentration on learning landings. And I would soon find out why.

A pilot who built his own Velocity won't need the system discussion, but someone who bought one would clearly benefit from it. Not all airplanes are alike and a pilot unfamiliar with the type will gain some useful pointers. (About half the training attendees are buyers; half are builders.)

The company is likely to have airplanes on the hangar floor, so the student can—as I did—paw through the airframes to learn about the fuel system, the landing gear hardware and the engine compartment. And there are things about pushers that aren't necessarily obvious, like the oil cooler being mounted in the nose of the airplane with hoses running aft through the cabin to the engine.

Meier says she advises pilots to uncowl the engine every 10 hours or so to see if anything has come loose. If it has, it's likely to go through the prop, offering an expensive lesson to the tractor pilot who wouldn't have thought of this, as I certainly would not have. Although I've flown pusher amphibs, I'd never flown one with the engine mounted at wing

Exploring the SE's flight characteristics includes a go at sampling the airplane's unique pitch buck. The slightest relaxation of up elevator command recovers it to normal flight. It's not capable of entering a deep stall or a spin.

Side stick or center stick? Depending on the model, Velocity has both. The V-Twin (left) has high-mounted side sticks with an armrest on the closed door. The center stick in the SE (right) is better thought of as a console-mounted side stick, which the pilot uses with his or her right hand. Dual throttle controls are mounted high on the outside edges of the panel.

level, so another lesson: The tires can kick up FOD and that'll go right into the prop, too, so watch where you're taxiing.

As noted in the sidebar, Velocity currently offers three models of its kits, the SE, the XL and the twin-engine V-Twin. Retractable gear is an option in the two singles, but standard in the V-Twin. The company keeps a fixed-gear SE in the stable for training and demo rides. For training purposes, it has a gear switch with indicating lights.

Off the Flight Line

As Danny Maher intended, the most notable thing about the Velocity SE is how spacious the cabin is and how easy it is to get into. The sills are unobstructed so you can just back your butt in and swing in your legs to follow. The doors are gullwing style and out of the prop blast, so you can taxi with them open with a gale of pleasant airflow that's a blessing on a hot Florida day.

Velocity's trainer SE is equipped with a Lycoming LIO-360—left turning prop—with one conventional magneto and one electronic ignition system. During ground school, Meier had reminded me that being a pusher, power changes tend to impart pitch moment—down when power is applied and up when it's reduced. While I have noticed this in amphibs with high-mounted pusher engines, like the Searey, I did not notice it in the SE or if I did, I automatically compensated.

As it should, the training concentrates on what's different about the Velocity compared to other aircraft. That's some, but not a lot. One is that to set the trim, you can just look at the elevator angle relative to the fixed canard. Meier teaches the finger method, by imagining the finger space in the angle formed by the elevator and the canard: One finger of deflection for one person aboard, two for two people.

Prior to takeoff, Meier warned me that the SE's center-console-mounted stick would impart a left roll on rotation

Velocity Kit Offerings

Velocity currently offers three aircraft kits—two singles and the V-twin. The two singles have optional retractable landing gear while the V-Twin has standard retractable gear.

The SE basic kit sells for $40,000, the XL (fixed gear) for $53,000. Because the V-Twin is such an involved project, it's available only as a fast-build version at $127,000.

These prices are aircraft only; no engines, no avionics, paint or interior fixtures.

The fast-build options for the singles break down into tiered choices. For example, a fast-build wing and canard set sells for $16,000. Those components come complete in primer, leaving the builder to install the control surfaces and circuitry. A fast-build fuselage sells for $11,000 and a retractable gear setup for $11,000. There's a long list of other options, including heavy-duty Cleveland brakes, a pre-wired landing gear hydraulic pack and an engine installation package, to name a few.

Otherwise, a builder gets foam cut to shape for the wings and canard and is on his or her own to do the composite work. The fuselages are also built of foam and are delivered in top and bottom halves for assembly by the builder. The kit prices include all the glass and resins necessary for assembly and pre-molded spars, strake fuel tanks and internal bulkheads.

Duane Swing says the company is producing a dozen to 15 kits a year, with the XL being the most popular model. Swing says the company needs about a month to deliver a standard kit and up to twice that for a fast build.

—P.B.

Velocity is currently producing 12 to 15 kits a year, across all models. There are tiered options for fast-build kits, with the retractable XL single-engine as the most popular choice.

With no wheels or wings in the way, ingress is an easy plant-the-butt and swing the legs into the cockpit (left). The airplane's winglets carry what passes for rudders (right), and although they work with the pedals, they impart more roll than yaw, meaning that you get better results by nudging the rudder first before rolling into the turn with aileron.

because the pilot tends to pull a little to the left while tugging aft for pitch up. Forewarned of this and fully prepared, I did exactly that, demonstrating my utter ordinariness as a pilot.

Having seen Long-EZs dawdle on the takeoff run, I thought the SE would behave similarly, but it seemed to accelerate smartly to the 70-knot rotation speed and my unintended roll not withstanding, it unstuck predictably and settled into the climb. The canard doesn't obstruct the forward view, but the glareshield does if you want to maintain a brisk climb rate.

Yank and Bank

The Velocity feels generally conventional in flight. Pull back and the houses get smaller, push left and right and it rolls. However, about those rudders: They're mounted vertically on the winglets, and those of us used to conventional rudders will find them a little odd. Any aircraft with a rudder will roll when input is applied, but it will yaw first and that speeds up the opposite wing and imparts the roll.

It doesn't work that way in a Velocity. There's little or no yaw, just the roll. With ailerons alone, the SE is stiff in roll. A little leading rudder cures that. "If you want to do a turn, you use rudder first, then coordinate with aileron and it comes around really nicely," Meier told me, and so it does.

Stalls have little resemblance to an airplane with a conventional tail. "The stall is very benign, but you have what's called a pitch buck," Meier explained. This is more vigorous than violent, but you wouldn't mistake it for turbulence. If you increase the pitch until the canard stalls, the nose drops through and resumes flying at the bottom of the arc and it will repeat this until the pitch command is relaxed. As noted, applying rudder would just impart roll, not yaw, and since the main wing isn't stalled, I don't see how roll-yaw coupling would ignite a spin. I didn't try and Swing says they've tried, but couldn't get the airplanes to spin.

Stall speed is about 62 knots and the onset of pitch buck is a bit below that. Swing told me if you timed the oscillations carefully, you might get the main wing to stall, but it would be a wild ride getting there.

Land This Thing

All of this was in preparation for the main event: learning to land a Velocity.

If that looks suspiciously like a motorcycle steering damper (left), it is. The nosegear on a Velocity does a lot of heavy lifting and needs help to avoid shimmy. Lacking flaps, the Velocity has the option of a flat-plate speed brake (right). Deployed electrically, it helps a little with the speed and approach angle.

One of the things that is different about pushers is that the props are more susceptible to FOD—both from the runway and from the engine itself. The odd loose screw or hardware that would drop to the bottom of a tractor engine cowl is more likely to spit out the back and ding the prop. That means it's a good idea to uncowl every 10 hours or so and see if anything is about to come loose.

Sounds simple. Isn't. Until you learn how to do and then it's "what's the problem?"

"One of the biggest things I find is that people want to start flaring at 50 feet or so. I have to get them out of that habit. It's essentially flying the airplane onto the ground. It's a very flat attitude, I don't even say flare. I say round out," Meier told me.

OK, got that part. But I've been flying little but taildraggers for the past 10 years, and Meier was about to ask me to do an unnatural act: land in a crosswind while crabbed. And there was enough crosswind to require about a 20˚crab.

Old muscle memory dies hard and I had difficulty doing the mind over matter required to land the thing in a crab. Further, the fly-it-on flat attitude requires quite a bit of hand-eye finesse. When the mains touch, the nose wants to come down right now, and you'll need quick and delicate reactions to avoid the slam.

"I tell people that to fly a Velocity, it's two landings. You want to land the mains and then the finesse part, when you get practice, is to land the nose," Meier politely informed me before I cratered the first landing. They got better, but the first one must have stressed the nosewheel tube because it went flat on the last landing.

The essential skill is to fly what feels like a ballistic trajectory to the runway. It's not really that fast; 70 knots over the numbers is only 5 knots faster than an RV might fly. But it's a flat, even approach angle that takes getting used to.

I suspect any pilot of average competence could take off in this airplane and get it back on the ground in one piece. But the airplane would probably suffer hellish abuse while you figured out how to do it right, further proving an axiom I learned more years ago than I'm willing to admit: This training stuff really works.

Approach speed is not especially fast, but it's flat when compared to other aircraft and the speed is held almost to the runway. Velocity's Ingrid Meier suggests there's no real flare, but rather a hint of a round out. Unnervingly for taildragger pilots, the airplane is landed in a crab in a crosswind.

BUYING USED:
Long-EZ

Construction workmanship varies greatly, so it pays to have experienced eyes look over your temptation before you succumb to its charms.

BY LEROY COOK

Over 40 years ago, Burt Rutan set the homebuilt airplane movement on its ear in 1976 with his unusual VariEze design. From its canard foreplane "tail" to its moldless fiberglass construction, the little Eze broke new ground in an age of staid tube-and-rag homebuilts.

Rutan wasn't the first to build and fly a pusher-type airplane with the tail in front, but he did solve the inherent weaknesses in the concept, flaws that had bedeviled the similar WW-II era Curtiss XP-55 Ascender fighter plane. Rutan's strength as a designer has always been to find innovative ways to successfully achieve a performance objective or limitation. For instance, when it was evident that the CG of an empty VariEze would cause the powerplant-heavy aft fuselage to drop to the ground, his solution was to make the nosewheel retractable. By cranking it up after disembarking, thereby parking the aircraft in a self-chocking, prayerful position, the awkward storage problem was solved.

History

Burt Rutan's Long-EZ, as the name implies, was introduced in 1980 as what appeared to be a lengthened version of the original VariEze, but in reality it was a complete redesign, not a simple scaling-up. The little VariEze began as a light Volkswagen-powered airplane, but it was soon optimized with the O-200 Continental pusher configuration. It didn't take long for builders to want larger engines.

Designed around a Lycoming O-235 engine, the Long-EZ not only had a longer, sleeker fuselage but a larger main wing with less sweep angle. The wing-root strakes were bigger, giving more space for fuel and baggage, and the cockpit was wider. With 52 gallons of fuel, the Long-EZ could stay aloft for as much as 10 hours. The easiest way to discern the two EZs is to look at the wingtip; VariEzes have short protuberances below the wingtips, under the tip rudders, something not usually present on the Long-EZ.

Photos: Marc Cook and courtesy of the Long-EZ owners

Prefabricated kits for easy assembly were never part of the Rutan Aircraft Factory's offerings. Plans and instructions were simply sold by RAF, and a bill-of-materials package was offered by major homebuilt supply houses. Thus, the builder is responsible for most all of the work seen in a Long-EZ offered for sale, and it is important to have a knowledgeable EZ builder/owner to help evaluate a purchase.

Cockpit of Michael Beasley's nearly completed Long-EZ, with two Dynon HDX displays running. Sidestick is on right, throttle quadrant and canopy latch are on the left.

As with the VariEze, the Long-EZ uses Rutan's moldless foam-core construction method, a brilliant, simple way to optimize shape by cutting or hot-wiring out a profile from blocks of high-density poly foam, sanding it to exact dimensions and laying on fiberglass and epoxy over the foam, as is done with surfboards. The result is a light, sleek airframe, giving very efficient aerodynamics.

The forward lifting surface, incorporating pitch control, means trim drag is minimized compared to conventional aft-tail aircraft. Stability is also enhanced, providing pleasant cross-country cruise characteristics, and EZs are essentially stall and spin resistant, nodding gently straight ahead when flown at the canard's critical angle of attack. The Long-EZ's canard originally used the same airfoil as the VariEze's, but a newly designed airfoil was introduced in 1985 that allowed the canard span to be reduced and largely eliminated the trim change that was sometimes experienced when flying in rain with the earlier airfoil.

The trade-offs, of course, are the limitations imposed by a pusher engine installation and tailless configuration. Rutan solved stability problems by installing winglets (tip sails) with independently actuating rudders on the end of the swept wings. The rudders can also be deflected simultaneously, acting as air brakes, by depressing both rudder pedals at once. Because of the intentionally imposed limited lifting ability of the canard, required so the main wing cannot ever be stalled in flight, slowing the sleek EZ down for a landing requires deflection of a bellyboard drag surface. Flaps are not available because trailing-edge lift/drag devices would upset the carefully crafted balance between main wing and canard.

The futuristic logo of the Central States Association newsletter, long a favorite communication and sharing medium for canard aircraft builders and flyers. CSA is now part of the Canard Owners and Builders Association.

What to Look For

As with any Experimental/Amateur-Built category aircraft, construction workmanship can vary greatly, so joining and seeking help from canard airplane clubs is important. Because Long-EZs were not assembled from factory-built kits, even though many prefabricated components were available from supply houses in the heyday, it pays to have experienced eyes look over your temptation before you succumb to its charms.

Terry Schubert, retired newsletter editor of the Central States Association (the CSA is now part of the Canard Owners and Builders Association as it had become much more than a regional group), gave us a lot of tips about EZ evaluation. He says to carefully consider the empty weight; excessive weight can't be fixed. Added poundage impacts performance and it compromises the G-load safety margin. He says an O-235 powered Long-EZ ought to come in at 850 pounds, without a starter, and he wouldn't consider one that weighs 1000 pounds as it would be a single-place plane most of the time. One with an O-320 engine ought to weigh less than 1050 pounds.

Then look the airplane over in good light, but not in glaring sunshine that hides imperfections. Look for rounded bulges in the finish that might indicate a delamination of glass from the foam core, which can only get worse

Owner Feedback
Mike Beasley
Central States Association Magazine Editor

Building my own Long-EZ and installing my own avionics and electrical system has provided me with an immense learning opportunity, one which made me a better builder and aircraft owner. I began my aircraft when I was stationed in Germany in 2001 while in the Air Force and subsequently moved my project three times. I am currently in final assembly and am planning the first flight in the next few months.

By all means, get to know the community of builders and flyers before seriously considering the purchase of a Long-EZ. Builders and flyers of these aircraft love their planes and want to tell you all about them! The community is filled with decades of experience and lessons learned, and a prospective buyer can learn a lot if they're willing to listen. Joining the Canard Owners and Builders Association is a great first step. The Central States Association magazine is published quarterly and consists of approximately 32 pages of extremely helpful information pertaining to the building and flying of canard aircraft. Beyond that, attend major fly-ins such as Sun 'n Fun in Lakeland, Florida; AirVenture in Oshkosh, Wisconsin; and other regional canard fly-ins that are listed on the COBA website. At these events a prospective buyer can talk with several owners and builders to get multiple perspectives of buying, owning and flying these awesome aircraft.

For potential Long-EZ buyers, I offer the following: First, the best option is to have a very knowledgeable person inspect the aircraft, someone who has built a Long-EZ or another canard airplane. Since these aircraft are scratch-built, the builder may choose to do something different than what's shown in the plans. These modifications should be considered carefully, and the average A&P mechanic who performs prebuy inspections on production aircraft will probably not be familiar with the intricacies of the Long-EZ.

Secondly, examine the build logs and the aircraft logbook. Do they contain detailed records of routine maintenance and other maintenance that has been performed? A properly maintained aircraft should have such entries to ensure proper tracking.

Next, take note of any surface irregularities on the aircraft's surface, particularly on the wings and flight controls. A simple "coin tap" in the area can be used to determine if the top layer of fiberglass has separated from the underlying foam core. Tapping outside the area of concern will result in a high-pitched sound level, but as the coin is tapped toward the delaminated area, the tapping will change to a lower hollow sound. While small areas can be fixed by drilling a small hole and injecting epoxy into the delamination and clamping or weighting it, larger areas are reason for concern and a more comprehensive repair may be in order.

Lastly, note the general quality of small details. I like to stick my phone through the leg holes in the cockpit toward the front of the plane and take several pictures. That enables me to review the photos in detail, zooming in to get a good look at the quality of work under the panel. Are aviation-quality wiring, connectors, splices, etc. used? How organized do the systems appear to be installed? If you encounter a problem after purchase, determining the source of the problem may be challenging if things are not organized.

To prevent this, ensure that all the aircraft's systems are documented in a set of drawings or diagrams. Even experienced builders can forget how they wired something after a few weeks or months and will need to rely on their drawings to troubleshoot and repair the aircraft. A new Long-EZ owner or A&P will have quite a challenge troubleshooting a problem if there are no system drawings *for that aircraft.*

Owner Feedback

David Orr

I've built one Long-EZ, and I have 4050 hours flying canards. I've refurbished several of them, including two Long-EZs and now the Cozy IVs and Berkuts.

When I was younger, I ran a club called Squadron II that eventually grew to include up to 100 Los Angeles-area canard airplane builders. Over time, some of the guys fell out of building and we helped find buyers for their projects. As time passed, I got involved in finding good Long-EZs, Long-EZ projects and even plans for buyers, and I've been doing that for almost 35 years. That has now expanded to include most of the canards. These are wonderful traveling machines, comfortable to fly, and life-saving in several unique ways. They have taken me to Fairbanks, Alaska; Puerto Rico; the Bahamas; and about 20 airports in Mexico from here in Los Angeles.

After I left Santa Monica, I formed Squadron III, basically a canard newsletter, and I stand ready to handle builder and many non-builder owner requests, such as, "My nosegear fork broke; where do I get a new one?" Squadron III is currently at 1145 canard owners, about half of which are Long-EZ people. I started out West and now it stretches all over the world, just like the Central States newsletter, which may be a bit more builder oriented.

Terry Schubert

Retired 30-year CSA Newsletter Writer, Editor and Publisher

Photo: Ronald J. Revelt

Pardon me if my bias shows, but I consider the Long-EZ to be the finest, most efficient, fast, stall-resistant, affordable, cross-country airplane in existence. I base this on 61 years of Airplane-SEL and -MEL experience, which includes nearly 4500 hours and 34 years flying time in my O-320-powered Long-EZ. Being in close contact with the worldwide family of canard airplane owners and builders through the Central States Association has further reinforced my opinion.

When first considering purchasing a Long-EZ, realize that all these airplanes are different and some are very different. The operating limitations were written specifically for that one airplane and will be different from other exact-looking airplanes. They govern what you must do to maintain and operate the airplane.

Second, you need to determine what your mission is: Will it be cross-country, breakfast flights, aerobatics, IFR, grass-field operation, etc? Just because canards look cool, that's no sign one is for you. Their 65-knot touchdown speed and hard surface requirements rule out many airports. I have watched Long-EZs do loops and rolls and they are *very* strong, but a Pitts looks and feels better. I know of none built with plans-specified structure that has ever had an in-flight structural failure, if not flying in a thunderstorm. There aren't many designs that can say that.

On the other hand, if you want to go from the Midwest to Sun 'n Fun nonstop in about 5 hours while reclined in comfort, with a softer ride in turbulence thanks to the composite canard configuration as your GIB is popping bonbons in your mouth, then this is the bird for you. Even if you are a potential world-rounder, you'll be happy to know that you can go 1650 nautical miles on standard fuel capacity, according to the specs.

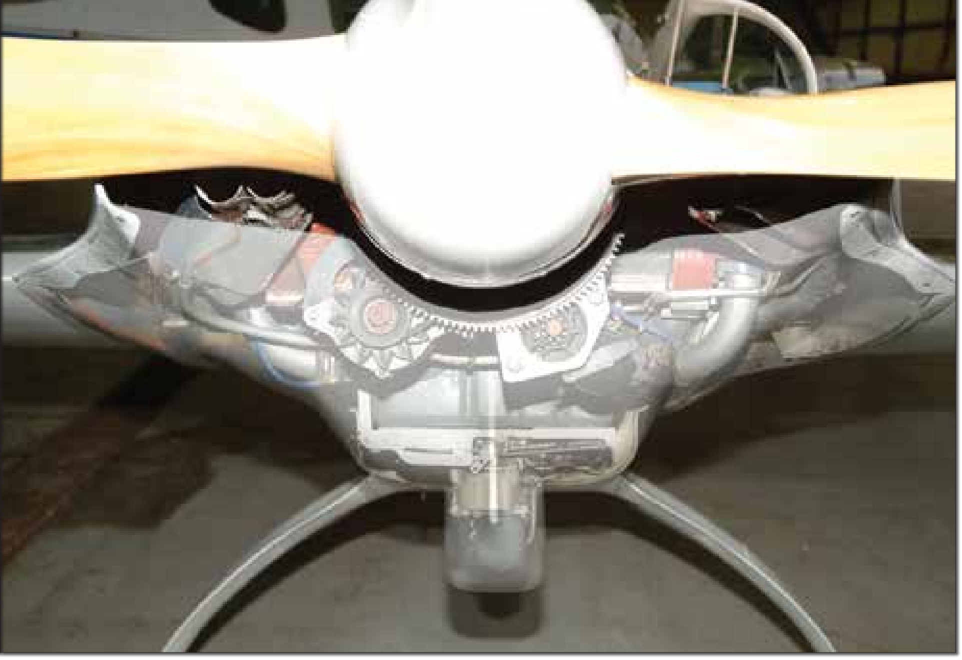
I am currently updating 34 years of the Central States Association newsletter articles to digital format and will soon be making them available to pilots and builders who are interested in cooling, drag reduction, maintenance and propeller efficiency, applicable to all airplanes, not just canard pushers.

Mike Sabourin's Long-EZ is shown in the main photos. For a walk-around video of his award-winning EZ, visit *www.kitplanes.com*.

under flight loads. With the nose gear retracted, stand at the rear and observe the underside of both wings; the amount of exposed areas visible should match, and if they don't there may be an issue with one side's angle of incidence. There should be no bare glass on surfaces exposed to sunlight, which invites UV damage. Paint should not be coming loose, which is probably a result of poor priming and may need removal and recontouring to fix. EZs are better off painted white or very pale yellow due to the room-temperature cure construction; heat soaked up by dark colors weakens the structure.

The nylon brake lines need to be checked for flexibility, even if shielded by insulation and heat shields, as they stiffen with age. Schubert likes to stick with two-blade composite propellers for their durability, efficiency and one-third less susceptibility to FOD. It's important that the fuel caps have restraining metal chains, he says, both for static electricity and to prevent their loss in flight, straight back into the propeller.

Schubert cautions against buying any airplane that has been operated on alcohol-based fuel, which attacks the tanks in the strakes. Watch for blisters and soft lumps in the tank structure, which are challenging to repair. A later mod changed the system from two vent lines to four; if there's more than



Terry Schubert's Long-EZ engine installation is artfully revealed in this double-exposure shot, taken before and after the cowling was installed.

15 gallons in a tank with the original vents, there will be venting of fuel overboard from expansion while parked nose down. The solution is to fuel up just before departure. The Long-EZ's direct-reading sight gauges are unfailing indicators of fuel level.

As with all airplanes, the engine should have been given frequent flying to get the oil up to 180° F to prevent rusting; Schubert says to pull the dipstick and look under the cap for signs of rust. He also wants to look at the four exhaust pipes for unmatched deposits and oily residue. Cylinder head temperature probes should be installed and working to keep a careful check on the pusher engine's cooling health, and the cowling should fit tightly to prevent loss of cooling air. See if there's a cabin heating system installed; not all EZs have them because the greenhouse canopy traps plenty of warmth, but one will be needed at 10,000 feet msl.

The control system should be checked for flutter-inducing looseness, including the rudder return springs, and the elevators need to be noted as having been balanced in the logbook. There should not be any trim tabs added to the elevators or other controls if properly built. The rudders come in two sizes, partial and full length; the later are termed "high performance" rudders.

Canard style is a debate among knowledgeable and not-so-knowledgeable EZ "experts." The original Long-EZ plans called for the same GU25-5(11)8 canard airfoil that was used on the VariEze, which could exhibit some pitch-down trim change if flown in rain and required a few extra knots for takeoff and approach if rain was present. In 1985, plans for a canard with a John Roncz R1145MS airfoil were introduced, which largely eliminated the trim change. Some Long-EZs have vortex generators added to the upper surface as an alternate fix. As Schubert points out, some of the original canards may not have been well contoured and therefore have no laminar flow to be disrupted by rain, thus exhibiting none of the pitch-down tendency.

Engine Options

If in pursuit of maximum performance, a Long-EZ builder will have opted for a Lycoming O-320, or even an O-360 for another 12 pounds of weight. Because the airplane was designed for the lighter O-235, the bigger engine and associated systems require some attention to CG and perhaps weight savings in other areas. Just make sure the airplane under consideration hasn't had the bigger engine installed without documenting the change in the logs and limitations.

If sticking with the O-235 for lightness and economy, while still enjoying impressive speed, some builders leave

Owner Feedback

David Adams

My Long-EZ is powered by an O-235 with high-compression pistons and dual Light Speed Plasma electronic ignition, which allows me to achieve over 205 mph. However, I plan to install an O-320 engine in the near future to go even faster. My EZ's current empty weight is 875 pounds; the bigger engine will probably boost that to 950 pounds.

I'm not only a Long-EZ builder but also a race pilot, flying Race 83 on the Sport Air Racing League circuit (www.sportairrace.org/sarl). I've participated in 78 races and have won the League championship seven times.

As an EAA flight advisor, I can't stress enough the need for a potential buyer to obtain professional help before buying a used Long-EZ. Because they are hand built, no two are alike.

I recommend three experienced canard-airplane builders for prebuy inspections: Marc Zeitlin in California, Burrall Sanders in Colorado and James Redmon in Texas.

Most importantly, new Long-EZ owners need to obtain and read all the Central States Association newsletters. Doing so will save a lot of wasted time and phone calls attempting to obtain already-available information.

Bob Holliston

I've built two Long-EZs. I spent two years building the first one, which I sold in 2003, and it took me four years to build the second one, which I flew for six years in all-white configuration before finally painting it pale yellow and green.

My airplane is powered by a modified O-360-A2D engine with 10:1 pistons, generating about 215 hp. For balance, the airplane is stretched by 14 inches and has the battery located in the nose. It can cruise at 200 knots, and for best economy I go above 14,000 feet to true 174 knots on 5.4 gallons per hour. I have no problem operating out of 3000-foot runways, typically using about half the length.

I highly recommend that potential Long-EZ buyers take an experienced EZ person to look at any airplane they are considering. If they're not careful, they're liable to get a piece of junk. A friend of mine bought the cheapest one he could find, and it took a lot of work to finally get it right. In my opinion, only Lycoming engines should be considered: O-235s if the airplane was built light or O-320s if performance is the main objective.

Scott C. Torneten

My O-235-L2C powered Long-EZ was built in 1985 and I purchased it in 2016, after doing considerable research and receiving plenty of help from other builders. I found that EZ builders are very personally attached to their planes and are reluctant to let them go—unless they are going to a good home.

I'm very pleased with my aircraft; it weighs exactly 850 pounds and delivers 160 knots IAS at low altitude, with a wood/composite propeller. I've flown it from Salt Lake City to St. Louis in under 5 hours, cruising at 17,500 feet msl, and it only used 32 gallons of fuel on the trip. Nothing else is as fast for the money.

Adams in his Long-EZ Race #83 making a pass for the camera.

off the starter and install a lightweight wood propeller. There's certainly nothing wrong with flying at 160 knots on 115 hp, although the climb rate will be slower than with an O-320.

Many Long-EZ builders have tried automotive engine conversions, including Mazda rotaries, and two-time builder Bob Holliston cautions against considering one, saying that they are four times as much trouble and are almost never successful. Stick with the tried-and-true airplane motors.

Common Modifications

As with all E/A-B scratch-built designs, Long-EZs are often customized by their builders, which is why it pays to have a knowledgeable canard-airplane expert help you evaluate a potential purchase. Some add-ons or changes are beneficial, some are harmless, and some can be dangerous.

Vortex generators, added to the forward or main wings, may provide some benefit if installed correctly. A Davenport-type coil spring shimmy damper on the nose gear is much preferred over the plans version damper, according to Terry Schubert. Not all Long-EZs have a boarding step to assist in climbing over the side, which would seem worthwhile. An electrically powered nose gear extension system, versus the standard manual crank, adds some weight, which is always the enemy of structural safety and performance. Most, but not all, Long-EZs will have a cabin heating system of some sort (exhaust muff, oil

Comfortable seating and storage room in the strakes are cockpit features of the Long-EZ.

radiator, electric socks), depending on their region of origin.

Canard airfoil modification, aka the Roncz canard, to minimize the effect of flying in rain, would not usually be seen on early built (pre-1985) Long-EZs. The Roncz canard is shorter in span, adds a couple of knots to the stall speed and is slightly heavier. Replacing the original canard with the redesigned one is possible, with considerable work, but not critical for most operators.

Flight Characteristics

Long-EZs are wonderful cross-country traveling machines, albeit somewhat snug and limited on storage space; using moldable soft luggage stuffed in the strakes is the key. They are stable and

Strake mounting the electrical panel is handy and frees up instrument panel space.

have long legs, burning less fuel for the distance than just about any other two-seat airplane. Forward visibility, particularly on approach, is obviously impacted by the canard.

If you're looking for short-field and unimproved airport capability, you'll want to buy something else. The airplane's small tires, relatively high liftoff and touchdown speeds, and the possibility of FOD damage to the pusher propeller do not lend EZs to STOL operation. Their strength is in efficient transportation.

The characteristic praying-mantis tie-down position means you will begin by lifting the nose and reaching inside to crank the nose gear down. It takes 8.6 turns to extend the gear over center and lock it in place; watch for the nose to rise and then dip slightly at the end of the cycle, indicating that the gear did go over center. Hold on and climb aboard to add the human ballast; hopefully, there will be a boarding step installed.

The futuristic look of a Long-EZ, even from behind, is one of its strongest appeals.

If you haven't hand-propped the engine before boarding, check and announce for a clear prop to the rear before cranking up. Canopy latching is critical; there should be a warning system to alert you to an unlatched canopy before takeoff. By the same token, the full bubble makes a great greenhouse in hot weather, so you'll want to leave it cracked for taxiing. Brakes, of course, are necessary for steering, so check them early and often.

Once the engine runup and the side-stick and rudder controls are verified, recheck the canopy latching and swing into position to launch. When the canard comes to life and the nose can lift off, gain another 10 mph and the main wing will break ground. The canard makes a great attitude reference for climbout. Climbing doesn't take long, with 1500 fpm rates with small engines and 2000 fpm or more with the bigger Lycomings. For best efficiency, get the EZ up to 10,000 feet msl where it does its finest work. For the O-235 engine expect to see 150 to 160 knots TAS at normal flight levels and upwards of 200 knots with O-320/O-360 installations.

Descent planning starts well out from the destination; the sleek Long-EZ doesn't want to come down and slow down. There should be a nose gear-up warning to get your attention with the power back. Extend the belly board for the approach and keep a sharp eye out for lower and slower airplanes ahead. The touchdown comes at 65 mph or so as the main wing quits flying, and then it's time to get on the brakes for slowing and steering.

Disembarking is the reverse of mounting; an occupant in the rear seat simplifies the urgency of lowering the nose to prevent a tip-up. A postflight inspection of the rear-mounted engine compartment is a good idea, since you're not walking past it at the nose.

Resources

The Rutan Aircraft Factory ceased operation in 2004. Plans remain available in unused and partially used state from former builders, so there are still some new Long-EZs being added to the 700 or so registered in the U.S. Support is found among the membership of the Canard Owners and Builders Association *(www.canardowners.com)*, Squadron III, and the Rutan Aircraft Flying Experience (RAFE) organization website *(www.rutanaircraftflyingexperience.org)*. TERF Inc. *(www.terf.com/RAFCDROM.htm)* has secured the rights to publish all former RAF materials for the guidance of owners and builders. ✈

A kneeling Long-EZ at rest, secure for tying down with its nose gear tucked away.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Mike and Laura Starkey's RANS S-21

Part 3: The build begins "small."

BY LAURA STARKEY

Rather than tucking them away right after inventory, we brought the empennage (tail section) parts straight into the workshop. The manual says that the rudder is usually the best place to begin, so we agreed to this plan. A favorite saying of Mike's is, "How do you eat an elephant? One bite at a time." I know it is a common phrase, but oh boy—did we have an elephant here!

To get started, we organized the larger skins and parts below the workbench, with the small parts and rivets stapled to the wood board on the shop wall. The labeling of the parts from RANS is very straightforward, so this was extremely helpful to me in organizing before building. We didn't waste any time. The very next morning following the days-long inventory, we began.

And Here We Go

The assembly manual has a "getting started" section at the very beginning, letting you know some basics of building an aluminum airplane. Since this is my first build, I wanted to start out right. There were some extremely good tips for how to proceed with each step of the build that I relied on heavily, such as having each of the manuals (text, parts and figures) open to the same part of the build, laying out all parts for that portion of the build and envisioning how the pieces are going to come together before you actually start assembling. Among the other useful tips: keep parts level during the build with wooden blocks as needed and maintain a clean work area at all times. Then there were tips on deburring all those metal holes and edges. It's worth mentioning that

The Starkeys begin co-building their plane with the frame of the rudder (above). They waited and planned for a long time to begin this journey together. After Clecoing the rudder skin to the frame, Mike declared, “We have a problem.” With the levels on both sides of the rudder (right) you can clearly see the offset trailing edge.

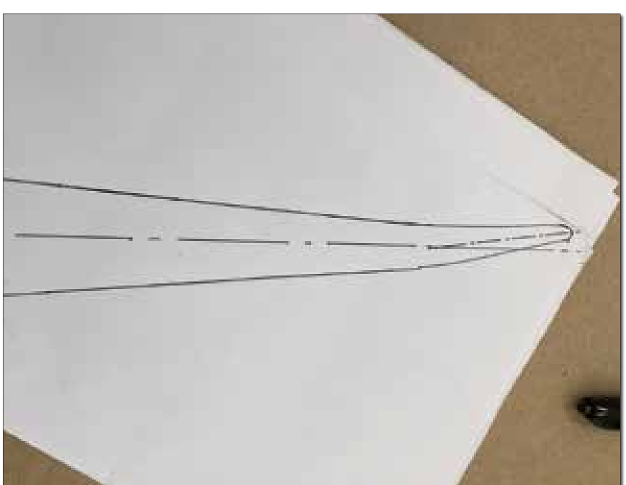
RANS has done a great job with the manuals’ organization. For example, the basics of metalwork are not repeated each time you need to do them. So you learn the basics of deburring once and let practice take care of the rest. But the reference is always there if you need it.

We started with the rudder frame assembly, where I got to pull my first rivet with the pneumatic gun. It was very exciting! (Remember that the S-21 is predominantly a pull-rivet airplane rather than using conventional driven rivets.) Like most metal aircraft, you start with the skeleton before you put on the skin, which seemed very logical for the nurse in me. Mike and I worked well together taking stickers off, deburring as needed and Clecoing the pieces together. Clecoes are a builder’s best friend, as I was soon to learn. And it’s true that you almost can’t have too many of them. Because they’re durable, they’re a worthy investment in tools.

When we Clecoed the rudder skin to the assembled frame, however, Mike said, “We have a problem.” Not words I really wanted to hear! He held up the rudder and you could see a bend on the trailing edge. A neighbor, who happens to have been a designer by trade, was visiting at the time, and the three of us soon came to the conclusion that the rudder skin itself had been bent by the factory in the wrong place. The three of us documented the bend, and we called it a day, frustrated.

The Wrong Part?

That night I kept mulling the issue over. I remembered reading on a “RANS Clan” post, “If you think the part is wrong, check again because most likely you’re the one wrong.” The following day, Mike and I removed the Clecoes from the skin and verified that the holes did not match up properly, so there was definitely a problem with the part. It happened to be Sun ’n Fun week in Florida and the majority of the RANS staff was there. Mike called the factory and was able to talk



With the assistance of Barry, a designer neighbor friend, the Starkeys clearly documented the bend in a pencil drawing to relay to RANS the issue they were having with the rudder skin (left). Here’s a side view of the rudder skin that had been folded in the wrong place by the factory (right). Much to their credit, RANS was quick to send a replacement skin.

Photos: Laura and Mike Starkey

Laura's happiness after fully riveting the vertical stabilizer skeleton together is in full view (left). Here, Mike is diligently transfer-drilling the side skin to the spar, with the holes on the leading edge skin acting as the guide (right).

to Eddie Gil, the builder we met when we toured the factory, and he said that they had a problem with some of the rudder skins not getting folded properly. He apologized and promised to get another in the mail to us. While it was frustrating to get started with a defective part, I was so happy that issue was resolved with the factory so easily! Kudos once again to the RANS folks for coming through!

As we waited for the rudder skin, we started on the vertical stabilizer. Being the process-oriented individual that I am, it bothered me that we were jumping to another assembly before having the first one done! I just tried to go with the flow.

One very important part of the prep work to building is having a straight frame. Mike was magic with the fluting pliers, working carefully to get the ribs to lay flat. With the frame now riveted and level, it was time to get the skins on. Side skins were Clecoed onto the frame and transfer-drilled to the spar with the holes on the leading edge skin as the guide for drilling. I inserted Clecoes as Mike drilled, and got both left and right side skins drilled and assembled. Leveling was checked several times and all looked good. We riveted the left-side skin and went to rivet the right side and noticed a great twist.

How could this have happened? I was mystified and confused. We checked for level several times along the way while we had it Clecoed together. But we didn't pick up on the twist until after one side had been riveted. We had our builder neighbors, Paul and Louise, come over for a visit to discuss our situation. Immediately when Louise saw our work, she put her finger on a spot where the left skin was offset ⅛ inch from the leading-edge skin where the transfer drilling had taken place. I could not believe that such a tiny amount of offset could be causing this huge twist. But Paul and Louise pointed out that a tiny mismatch like that amplifies itself through the entire part and can cause this much of a twist. That was so hard for me to believe!

Dreaming of Metal

I had another night of dreaming about a twisted vertical stabilizer. I know it sounds crazy, but this stuff can really get to you. Since it was the weekend, we had time to think about our options. We could either see if we could repair the skin(s) or replace them. We had to do more analysis on it to try to exactly identify why it was off. Mike and I both came to the conclusion that we needed to remove the rivets from where the left side skin met up with the leading edge skin on the spar—where the transfer drilling had taken place—to see what would happened to the twist. When

These are the early stages of Laura's newfound obsession with riveting. Like all good builders, she started with the small pieces to get used to the feel of the pneumatic gun.

This ⅛-inch offset remained after riveting the vertical stabilizer skin (left), causing a twist in the whole stab. Once the rivets were removed, the pressure was relieved and the skins relaxed and matched perfectly (right). The transfer holes were obviously offset.

we removed the final rivet that was in the spar connecting the two skins, it seemed to have a lot of tension on it, and when it was drilled out the skins relaxed into place and met up, even as could be! It was flat and the right skin was fine. We had found the culprit—exactly as Louise had identified. The holes on the left side skin where it had been transfer-drilled to the spar were mismatched and we decided that replacing left skin was our option. We photographed our issue and sent it to RANS on Monday requesting a new stabilizer skin and more rivets.

The explanation was actually quite simple. Mike and I had been incorrect in the way we were checking for level. We did not fully understand the directions. The manual tells you to measure off a Cleco in the end rib, and that made no sense to us. Mike had been checking for level by measuring the height of the leading-edge skin instead, but had to estimate the exact center of the curved section.

We finally figured out what they meant! There are tiny holes in the web of each end rib for this purpose, but we thought they were talking about the

Time to move on to the horizontal stabilizer with the assembly of the under-skin skeleton. Here, the ribs have been straightened, parts prepped and Clecoed together.

Mike finalizing the assembly of the horizontal stabilizer frame (left). Once the frame is completed on the horizontal stabilizer, it is on to Clecoing the skin and time for Laura to do some more riveting. You will need more Clecoes than you can possibly imagine!

rivet holes in the flange of the rib. Now we figured out that mystery!

Going forward, Mike used one of his cool tools, a Starrett machinist height gauge, that could pinpoint an exact height off the Cleco in the end rib to precisely check the part for straight and level. Paul also had a helpful hint that the best way to transfer-drill a piece of metal like this is to use a few Cleco clamps on the skins, start at one edge that is matched up and then drill from that end first. That way it sets the metal in the correct position and you can Cleco as you drill. Mike used Cleco clamps, but had started drilling in the middle of the piece. I noticed that it didn't exactly match up when we were doing it, but didn't think anything of it because it was "so close."

Lessons Learned

Here we were. The first two parts that we started on our build ended up needing to be replaced. And that's not a great feeling! We talked to Shelly at the factory after they returned from Lakeland, slightly delayed due to weather, hoping to get both pieces sent in the same shipment. But the RANS staff at the factory was so efficient that the replacement rudder skin had already been shipped, so this replacement piece would be a separate shipment. We also could see that we were going to need more rivets, so we ordered some extras. One thing I learned is that not every rivet is perfect (builder error) when pulled, thus some spare rivets for errant pulling are a must.

I was getting frustrated, so I took the day off while Mike forged ahead. His next task was the frame assembly of the horizontal stabilizer. This gave me time

Time to go back to the vertical stabilizer (left) and transfer-drill starting at one end. The S-21's prepunched design makes this task relatively painless. Laura, getting into riveting (right), sometimes decides that sitting on the table offers a better reach.

Back to basics: The elevator frame pieces get laid out (left) before assembly to help us understand the orientation of the pieces and the work that lies ahead. A bit later (right), here's the elevator frame assembled and the trim tab Clecoed together, ready for riveting.

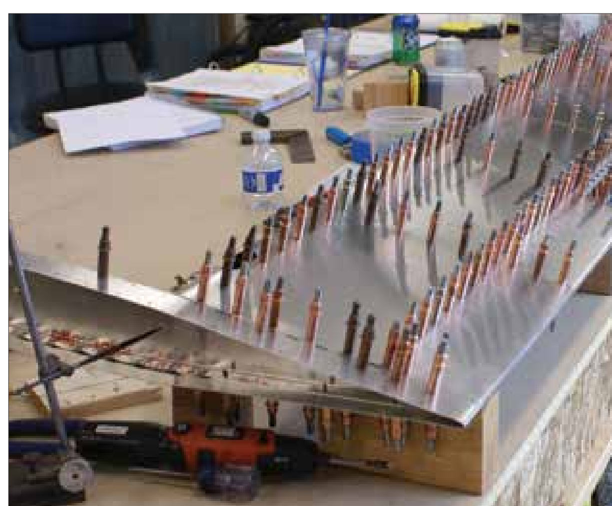
to reflect on where I was at with the build. Being the process-oriented person that I am and having had a third meltdown for "doing things out of order," I had to come to grips with the reality of building your own plane. Yes, it's that second-favorite phrase: *things* happen!

This is a fundamental truth of homebuilding. You may not know what's around the corner or what your next obstacle is going to be, but there will be one! Deal with it. I had to understand that the manual is not written like a book—with a beginning, middle and end. And not all the steps are laid out in exact order. I suppose I was expecting to build smoothly from one step to another. But those of you who have built before know this as well as anyone—there's nothing linear in airplane building. I finally had to learn that when you meet a roadblock, you don't stop. You figure out a way around it and find something else to work on. This one was a tough one for me, but I was much better off when I realized this was the way it was going to be.

Back to the Stab

The horizontal stabilizer is huge in comparison with the rudder and vertical stabilizer! Mike had the frame assembled, and now it was time to move on to the skin. Mike up-drilled some holes that needed to be bigger, while I followed with the Cleco, un-Cleco, deburr, re-Cleco, and *level, level, level*. Finally, riveting. I was also just learning that the repetitive nature of this work is just that—very repetitive. Not only that, it takes longer than you think it should if you want it done right.

Another finishing step I learned is that I like to have smooth rivets—Any mandrels sticking out and sharp are not acceptable, so I marked any rivet



Here are the hinges for the trim tab Clecoed in place on the trim tab and elevator (left). Mike had a "good time" fitting these gems! The side view of the elevator (right), shows how it is Clecoed up and verified before any riveting takes place.

Laura thought she was sunk when it came to riveting in a tight and narrow spot (left). But Mike had the answer—bend the mandrel outward, place the wedge on the mandrel, put the pneumatic gun on, push down firmly and pull the trigger (center). Success (right)!

that was sharp and sanded down the mandrel so the "final product" had no sharp edges. DNA samples from your own flesh are going to happen during the build, but try to minimize them if possible. Flip it, check for level and rivet the other side.

I learned early on that I loved to do the riveting because it gives me great satisfaction to pull a nice rivet! I even got to the point that one type of rivet became my favorite, because it was pretty, which made me wonder if, even at this early stage, I had already been doing it too long! We got the horizontal stabilizer done and what a great sense of satisfaction! It was level, no twisting and looked really nice! The feeling of satisfaction that comes with successfully completing a part had finally been established!

Return to the Scene of the Crime

While completing the horizontal stabilizer, we received the replacement skins for the rudder and vertical stabilizer. We decided to work on these pieces before taking on the elevator. We were really relieved to see the rudder skin holes match up evenly where the fold was, and once Clecoed onto the frame it looked perfect! In fact, it fit like a glove—what a relief! With renewed confidence, we did the magic cycle of Cleco, un-Cleco, deburr, Cleco, rivet, flip and repeat—checking for level frequently, of course. Soon enough, the rudder was done. Such a relief.

It was on to the vertical stabilizer next. It's unnerving to redo a part that you know you messed up the first time, but at least we understood where we thought the error had been and could forge ahead with the task! We had to drill out all the rivets on the old skin, remove it and replace it with the new skin. We Clecoed it all up, leveled it and, according to the directions, this time based on the holes in the end rib web, began transfer-drilling at one end with the Cleco clamps in place. After that, we tacked it down at one end on the forward spar, drilling with the metal perfectly aligned and working toward the middle, then followed the standard practice of locating a Cleco every other space as we pulled rivets. It worked beautifully, plus there was no twist. What a relief to have these pieces behind us!

Next up, the elevator and trim tab. This was the most involved part encountered on the build so far. Mike read the manuals trying to understand how it was all to come together and seemed to have a good grasp on it, though I was puzzled in a few places. For example, Clecoing the leading edge of the elevator skins to

Smiles and matching T-shirts. Mike and Laura completed assembly of the tail pieces, learning a lot along the way. They're fully prepared for the big parts that come next!

a piece of PVC pipe to make the metal curve in just the right way...well, that seemed pretty bizarre to me! By now we'd begun to trust RANS even more, so we followed the instructions to the letter. And what do you know: They actually turned out great!

The trim tab itself was not too hard to assemble, but the tweaking involved with getting the hinges mounted on the trim tab and the aft part of the elevator were quite the trick for Mike. Colorful expletives from him filled the room.

Up to this point, we had been working with relatively small parts. With the elevator, I learned that it takes more time than I thought to get this large of a piece done. I also learned that not 100% of your rivets are going to be perfect. Some will need to be drilled out and done again.

I learned another lesson about riveting, one which I will not soon forget. I came to a "tight spot" on the bottom skin near the elevator horn that the tip of the rivet gun would not fit. What the heck was I going to do about this?

When I asked Mike, he just smiled and went and got his pliers and this little aluminum wedge with holes drilled in it. He bent the stem of my rivet, placed it in the hole near the horn with the mandrel bent away from the work, put the aluminum wedge over the stem and said, "Pull it." My first thought was, "That's not going to work." But I decided to trust Mike on this one, so I put the rivet gun snugly down on it, pulled the trigger and, like magic, it worked. I was so excited—just like a little girl, jumping up and down laughing! I thought I was sunk and here he had such an easy answer to my dilemma.

With the finishing touches to the elevator, we had just completed our final part of the tail section. This was much more of an emotional roller coaster than I ever anticipated it would be. We'd experienced failures and been baffled. But we also had many wonderful hours of working side by side, brewing conflicts and crafting resolutions—then sharing our sheer joy over the victories. Maybe building an airplane is only part of the point. ✢

Zenith Goes Virtual

Stuck at home? It might just be time to start building the plane of your dreams.

BY KATE O'CONNOR

It would be fair to say my plans for the month didn't originally include building a rudder in my spare bedroom. However, when the opportunity arose to participate in Zenith Aircraft's first-ever virtual rudder-building workshop, there was no way I was going to miss out. Since airplane building wasn't something I'd tried before, I honestly had no idea what to expect. Luckily, it was a very pleasant surprise.

The move to an online format for the workshop came about due to the travel restrictions and social distancing practices necessitated by the coronavirus (COVID-19) pandemic. The workshop was run by Zenith's Sebastien Heintz and Roger Dubbert, and focused on the STOL CH 750 Super Duty rudder. To hold on to the camaraderie of an in-person group build—and get professional eyes on our work—each participant set up a camera or two at their workspace.

Finding My Workspace

There's a lovely workshop on the family farm where the communal collection of tables, tools and spare two-by-fours live. Normally, I haul any building projects that come my way out there so I can eat my aunt's cooking, use her (better) tools, take up too much of her workspace and

It turns out that the dogs' travel crates made a pretty good base for an impromptu worktable (left). The rudder kit arrived in great shape in spite of being all but kicked out the back of the delivery truck (right).

generally pretend like I'm 16 again. However, with several states and a couple of coronavirus-prompted stay-at-home orders between me and construction comfort, other arrangements were necessary this time around.

Having spent a few years in Boston, I've lived in much smaller apartments than the one in which I currently reside. That said, finding a spot to put together a functional workshop was an interesting conundrum. After consulting with the other similarly shut-in denizens of our abode, the second bedroom was sacrificed for the cause and agreements were drawn up regarding the exchange of baked goods for a day of listening to riveting without complaint.

Once the furniture was moved, I started staking out the apartment complex for additional materials. The day before the workshop, I struck gold and came across several freshly discarded pieces of wood tucked behind the waste bins, including a 4-foot-long section that made a nearly ideal tabletop. Using the dogs' travel crates as a base, I finally had a useable worktable.

Homework

When I signed up for the workshop, Zenith sent along links to a collection of online resources aimed particularly at getting first-time builders up to speed. Topics included using blind rivets and Clecoes, the art of deburring, tools needed for the project, drilling out bad rivets and adding corrosion protection. They also sent links to several videos of full CH 750 rudder assemblies.

In addition, the rudder kit came with an introduction manual. Along with providing information similar to that reviewed in the online resources, the 26-page manual touched on everything from basic sheet-metal construction and materials handling to time and cost planning for homebuilders. It's also where the step-by-step assembly guides and illustrations for the aircraft are located.

Being new to this whole thing, the supplemental resources were an excellent and necessary starting place for me. They were clear and concise without being overwhelming. All in all, it took me about 3 hours to go through the how-to materials before getting started, which definitely felt like time well spent.

Setup

The rudder kit arrived a day before the workshop. Given that I first contacted Zenith about participating just 10 days earlier, I was amazed at how quickly they were able to get me the kit and the tools. The rudder kit itself was securely packed; all the parts were well wrapped and arrived in pristine condition. I unpacked and verified the inventory with the included packing list. As part of the separate toolkit they offer, Zenith supplied a hand riveter, Clecoes and Cleco pliers, a measuring tape and drill bits.

Perhaps the peskiest thing about getting the parts ready was removing the stickers with the part numbers on them. They proved to be infuriatingly

Tools, fasteners and parts laid out in preparation for the workshop. Given the space constraints, I was lucky there weren't more of them.

Even without the instructions and demo, the factory predrilled parts made it fairly easy to tell if the pieces were in the right place (left). They're designed to fit only one way. With the first rivets set (right), the project was properly underway.

tenacious. After experimenting with a few of the recommended removal methods, I found—admittedly much to my surprise—that a one-to-one solution of baking soda to coconut oil, rubbed in with a cloth, worked best.

I did use a flat file and a drill bit to deburr the parts before getting started. It was around that point I discovered my drill was MIA. With less than 24 hours until go-time and not being able to venture out to get a new one, I did without. That led to being very, very careful about how I was setting the rivets and occasionally having to use a bit more brute force than I would have preferred. For this project, it ended up only being a minor issue but not one I would care to repeat.

Zenith offered two optional setup sessions via Zoom prior to the workshop. The first was primarily an opportunity to get to know our fellow builders and to pepper Sebastien with questions. During the second, he inspected our workspaces and camera arrangements along with offering setup tips and discussing how the workshop itself would run. I attended both sessions and found them to be useful and informative.

The Workshop

The workshop started at 9 a.m. Central time. After a quick round of intros, Roger walked us through assembling the rudder skeleton, demoing the process as we all worked. Once the majority of the participants were finished with a section, he moved us along to the next. He and Sebastien kept an eye on us builders

Although the factory itself was almost empty, almost a dozen builders kept the live-streamed workshop lively (left). The Zenith team (right) did a fantastic job answering audience—and builder—questions as they came in.

Once the ribs were in place against the main spar, the rudder really began to take shape (left). With the skeleton fully assembled, its was time to fit the skin (right). Note the prepunched skins and substructure.

throughout the day and offered suggestions and corrections as needed.

The building process itself was remarkably simple. Since the rudder parts are all predrilled and bent—and aren't heavy or big enough to need a second pair of hands—it was mostly a matter of lining them up, clamping them together and riveting. That said, there's a huge difference between my amateur ability to make all the bits stick together and the craftsmanship displayed by the people who knew what they were doing.

For me, that's where attending the workshop made the most difference. I picked up a lot of tips on how to approach the project, tricks regarding tool use and a heads-up about trouble spots to watch for that likely would have taken me forever to sort out on my own.

Over the course of the workshop, the crew at Zenith took breaks from the build to give us a look at what else was going on over in Missouri. They started with taking us through using the 3D SolidWorks model of the aircraft, something I can imagine would be invaluable to those lucky enough to be building more than just the rudder. They also gave us a walking tour of the factory—where we all discovered that their Wi-Fi doesn't quite reach the far corners of the facility. Zenith staff, quick on their feet, quickly addressed this problem with a switch to a cellphone camera. Once recovered, they

Roger demonstrated each section as the workshop progressed, along with keeping an eye on the builders via multiple screens.

went over a completed Super Duty. There was mention of doing a demo flight, but the weather never cleared up enough to allow for a virtual ride-along. They have since posted a virtual demo flight to their website and YouTube.

During the extra activities, participants could either stop and watch or keep building as they preferred. Given that I was using a hand riveter, I mixed and matched depending on just how much I was missing my air compressor at the time. We wrapped up around 2:30 p.m. with almost everyone having completed their rudders.

You know it's the homestretch when there are more pulled rivets than Clecoes!

Takeaways

The folks at Zenith struck a great balance between informal and directed. It was easy to ask questions and get help without feeling like we got off track. Overall, the pace felt just about perfect, and I was comfortable that if I was messing anything up too badly, it would be spotted.

On the technical side, the workshop went smoothly. Other than the minor glitch with the factory tour, the livestream worked out very well. The demo rudder was easily visible and the audio was clear and didn't lag. Even knowing that they have a fair bit of experience filming their products and doing demo builds, the quality of the event made it a little difficult to believe that this was Zenith's first live virtual workshop.

As a bonus, the workshop was streamed on YouTube and Facebook. People viewing it on those venues could comment or ask questions, which were then relayed to Roger and Sebastien. The audience participation aspect made for some good questions and additional helpful tips.

While I wouldn't want to see Zenith switch to doing only online workshops—and I very much doubt that's their plan—the ability to hold them seems to be helping the company reach people for whom making the trip would be challenging. One participant had his young children helping off and on during the day, which likely would have been difficult, if not impossible, to do at the factory. For my part, it meant I could take half a day for building and be back at my desk in time to turn out a few news stories for our sister site, AVweb.

As a first-time builder, attending the workshop provided a lot of useful support. It helped to know that if a problem arose, there were several highly knowledgeable people on hand to get it sorted along with providing extra eyes to catch my newbie mistakes. It was also just plain (plane?) fun!

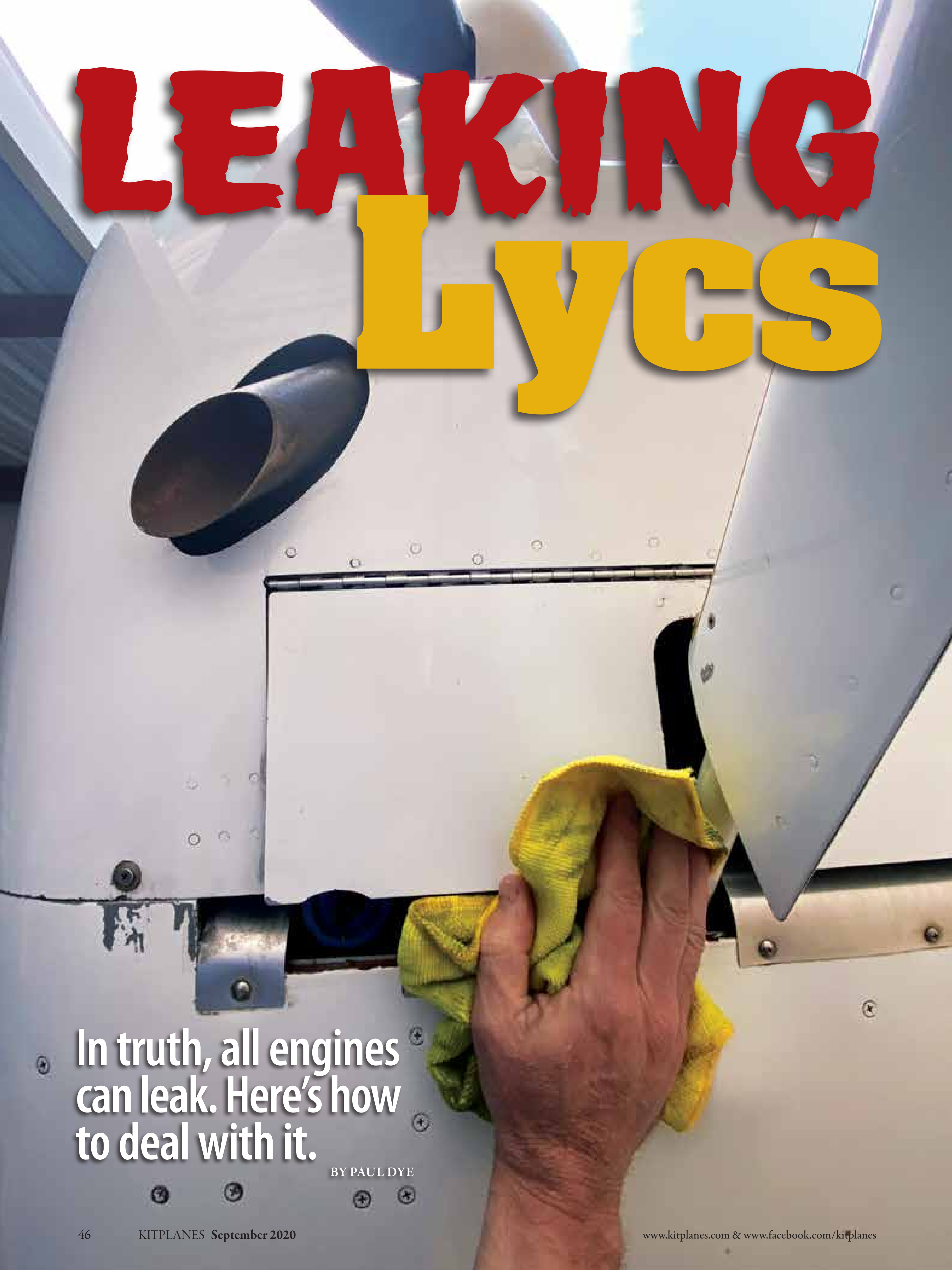
Building My First Airplane (Section)

The first time I helped my father bend cedar strips for a canoe, it seemed a little like magic. Somehow, the boards that had been stacked in the workshop for weeks—minus a few hours floating in the bathtub—twisted themselves into entirely new shapes and, bit by bit, turned into a boat. While the medium was different, there was a lot about airplane building that felt the same.

I'm not sure what this project would have been like if I hadn't spent most of my life with tools in hand. As it was, although I hadn't used a riveter or Clecoes before, a few minutes poking around YouTube and a bit of practice were enough to be getting on with. That was my experience with most of the Super Duty rudder build: With a little research and the right tools, it was a relatively easy—and highly satisfying—undertaking.

All told, in somewhere around four and a half hours, I managed to turn a pile of metal into an identifiable airplane section. Having accomplished that much, it hasn't been all that hard to imagine picking up another section somewhere down the line, which is how I'm going to end up being that crazy person who built an airplane in her apartment.

—K.O.



LEAKING Lycs

In truth, all engines can leak. Here's how to deal with it.

BY PAUL DYE

Coked oil on the muffler or heater shrouds is a sure sign of a leak, but it is only one clue about where it is from. Oil can come from anywhere and end up everywhere.

One of the best things about my little jet (with a top-mounted engine) is the complete lack of oil on the belly! I never have to worry about crawling underneath with a solvent-soaked rag to get the grit and grime off before it ruins the paint. But pilots and owners of homebuilt piston-powered aircraft everywhere (including me) go to great lengths to keep their machines' bellies clean. Oil attracts dirt and dust from the runway to make that gooey black mess, and the more oil that comes out of the engine, the worse it gets. Of course, those with pusher configurations can laugh along with jet drivers—if there is no belly downstream of the engine, you have nothing to clean!

Oil separators are one way to reduce the mess, but many are disappointed that even after going through the effort of installing one, they still have oil on the belly. The problem, of course, is that while an ideal engine sends oil only out the breather line, in the real world, oil can leak from all sorts of different places—despite the best efforts of design engineers and mechanics.

Lay of the Land

The typical aircraft engine—whether that's a true-blue Lycoming, a so-called clone or even a similar large-displacement, air-cooled powerplant—might start out dry and clean, but it is not uncommon for leaks and drips to develop after a hundred or more hours. Things shift, seals take a set, and eventually you find that before you can do a decent inspection, you have to buy a jug of Stoddard solvent and a cleaning gun.

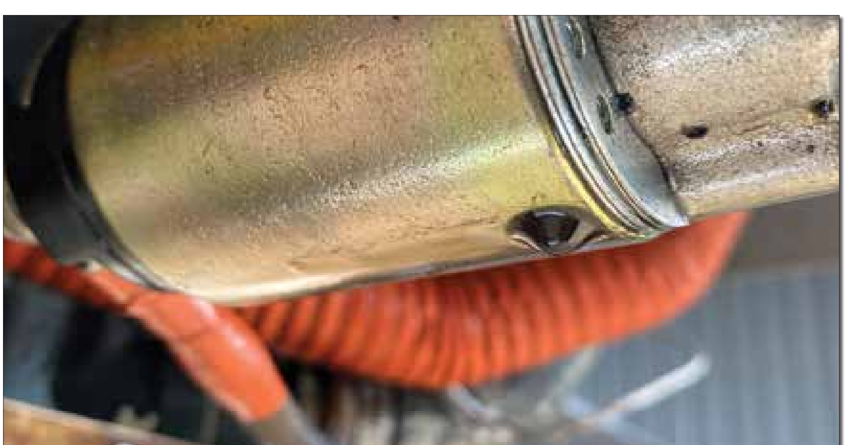
That engine cleaning is the first step in tracking down any leak. Airflow underneath a cowling goes in odd directions, which means leaks are not necessarily where you think they are. I have seen leaks from rear-mounted accessories show up as drops of oil on the starter—it's all about how the air carries the oil around.

So clean things up—and I mean thoroughly, like you're planning surgery in there—then go run the engine for a little while. If you think you have a big leak, run it just a short time or the leak will spread enough so that it is hard to localize. If it is a minor leak, clean it up and go fly for half an hour, then come back and de-cowl to check it out. If you started with a clean engine, the leak location should begin to give itself away.

It's important to be systematic. If you just bop around the engine compartment randomly, you'll probably miss your real problem. The other thing to remember is Occam's razor, which states that in most cases the simplest explanation (or solution) is usually the correct one. Leaks either come from fittings, seams or cracks—and since cracks are comparatively rare, they should probably be the last on your list. Start with the easy stuff that is most likely, and let the big worries move to the back of your mind. You'll see why I say this in a moment.

Start Simple

Begin your hunt for leaks at fittings—any place in the oil system that has a B-nut that you can put a wrench on. Check them all! Start at the top front of the engine and work your way down and aft—or if not in this direction at least systematically. If you have a constant-speed



It is very common to have an oil drop off the bottom of the starter (left). There is nothing to leak there, however; airflow under the cowling just moves oil to that spot. It's easy to tell if oil is leaking from a pipe thread fitting (right). This one is dirty but not oily.

Photos: Marc Cook

Check the oil cooler fittings—both the pipe threads where elbows screw in to the cooler and the hose ends (left). Overtightened elbows can crack the cooler boss—undertightened ones can seep. Silicone rocker valve cover gaskets (right) help keep oil in—but they leak if overtightened, so go slow on those screws.

prop, check the governor line fitting on the nose piece, then move aft and check the oil drain-back line fittings on each cylinder head. On the back, check the prop line on the governor, then all of the hose fittings for an oil cooler (if you have one). Check the oil line that goes to the oil pressure sensor as well. In short, if it has oil in it, check for tightness!

A very common source of oil on these engines are the rocker-box covers. Look for drips on the bottoms of these, and check the screws for tightness while you're there. If you still have the original cork seals, consider replacing them with the orange silicone seals. But be careful not to overtighten the screws if you do—the torque recommended for these is very low. Tighten a little, then run the engine and tighten a little more if you see drops from the bottom screw.

A huge number of leaks can be found this way—fittings can loosen over time. More likely, they weren't tightened properly in the first place. Checking fittings for tightness should be done at every inspection—make it a habit to check them all with a wrench at every condition inspection. One other possibility to check, if you feel that a fitting is really leaking, is to remove it and look at the tubing flare to make sure it is properly done, has good contact all the way around and isn't cracking, I have seen defects for each of these cases in flying airplanes.

Now while we're just poking around, let's do one more thing—let's check for a crankshaft nose seal leak. Grab a flashlight, inspection mirror and a clean paper towel. Take a look up and inside the flywheel—this is most easily done with a mirror and by looking up above the alternator, most baffles and the starter block; there's good access anywhere else. See if you see any sign of oil in there—if so, it can only really come from one place. If you're not sure, take that clean paper towel and wipe the inside of the flywheel—that will tell you if you have any oil in there. If so, add this to your list of things you might have to go back to.

Moving Along

Next thing to check is anything secured with a hose clamp—the couplings for the oil drain-back lines underneath the cylinders, for instance. The factory-designed clamps for these rubber tubes are worm-drive hose clamps, two for each short piece of hose. Unfortunately, the nature of a worm clamp of that size is that it will not put even clamping pressure all the way around. Owners of Lycomings have struggled with leaks here for a long time and many are now substituting automotive-style spring clamps that are installed with pliers; they tend to evenly clamp the hose for its full circumference. It's not factory, but your engine is on an Experimental, so if you have trouble with leaks here,

Oil return-line couplings (left) are always good places to check for leaks, especially with worm-drive clamps, which don't seal well. Tightening them rarely makes them seal better. It is not uncommon to find drops of oil on the fuel pump screws—but it rarely comes from the fuel pump (right). This oil is most likely coming from above or ahead.

Typically, you'll want to look above for the source. For example, if an oil filter is loose enough to leak, it is *really* loose (left). Rarely is this the cause of a drip unless you have debris in the seal. Leaks from magneto seals are common (right). If you have a leak on the back of the engine, check to see if these are the source.

the new style clamps are worth a try. Also, if the hoses are chewed up by the clamps, replace them.

Continuing our search at this level, we are basically looking for any place that a "soft seal" might be leaking. It is important to remember that Lycoming's recommended TBO (which we are not required to observe) is generally expressed as a number of hours *or* a number of calendar years—2000 hours and 12 months being applicable to most of the four-cylinder, direct-drive, horizontally opposed engines. Hours in service is a criteria that is easy to understand—it is a measure of potential wear.

But what's the deal on those years? Seals are soft goods that age and become stiff or brittle with that age—so a growing number of leaks in seals is an indicator that you might be ready for a teardown and rebuild. If your engine is low on hours but high in years, you might be able to get away with a simple reseal without having to do a complete overhaul. But in having it apart, I bet you'll find corrosion (the result of few hours in a lot of years) and need to go the full overhaul route anyway. I'm not saying that you *have* to tear your engine down after the age requirement, by the way—I am simply saying that if you're getting leaks with age, it might not be unexpected.

The breather fitting can leak if the hose is old and gooey, so check to see if you have oil seeping out—especially if you have done any zero or negative G maneuvers (left). The breather exit can send oil overboard—that is its purpose (right). If it is terminated in the cowling above an exhaust pipe, it's worth checking to see if there is a lot of oil coming out.

But before we entertain such a painful thought, let's move to the back of the engine—where the accessories live. Most likely, you have a fuel pump, an oil filter (and adapter) or screen, magnetos (or ignition pickups), a prop governor and a vacuum-pump pad. Each of these has fasteners and gaskets that could leak. Use a bright flashlight to look for leaks, then put a wrench on every mounting bolt or nut and make sure everything is tight. The good news on accessories—if you find a leak from a gasket, it's relatively easy to buy just the gasket you need, pull the device, replace the gasket and fix the problem. It is especially common to have mag gasket leaks, by the way; these often get disturbed in the process of timing the ignition and then they don't seal.

Don't overlook the crankcase breather line, either—usually there is a short length of rubber hose at the top and the bottom is often terminated above an exhaust pipe, plumbed into an oil separator or just vented into space. The good news is that if these are leak sources, they are generally easy to find and fix. Just tighten the appropriate clamp.

Before we leave the area of seals, let's go back to the top of the engine and take a look at pushrod tubes—all of them—and both ends of each. It is fairly easy to see the end that tucks into the crankcase, and a leak there—from the green seals—should be obvious. The end at the cylinder head is a little harder to see, however, and is sealed with an O-ring that can deform and leak with age. If you find caramelized oil on the exhaust port or around the lower spark plug, think of where it is coming from—the outboard end of the tubes is the likely culprit. The seals on both ends can be changed fairly easily with just a little investment of time.

Bigger Problems

If you have tightened all of the fittings and hose clamps—and still have a leak—you might have a problem that is a little more difficult to fix. The major joints on the engine include the one between the two case halves, the sump attachment plane and the accessory-case joint on the back of the engine. Add to these the base of each cylinder, and you pretty much have all the places that are sealed by gaskets of one kind or another.

If you have a leak at the base of a cylinder, oil is somehow getting past the cylinder base O-ring. The only way to fix this is to remove the jug—not a terribly difficult thing to do once you have the baffling removed. (I can see the wind go out of your sails with the mention of baffling—but sometimes you just have to bite the bullet and remove the tin.) If you have to pull a cylinder to replace the O-ring, understand that it is invasive enough that you'll want experience on your side—either your own or from someone who has disassembled and reassembled a Lycoming before. Again, it's not a difficult job, but one that is more involved than we'll discuss

If you find coked-on oil around the lower spark plug or exhaust gasket, the most likely place to check is the outboard pushrod O-rings (left). These don't last forever and are likely leak sources after 10 years or so. The inner pushrod seals can leak when they get old (right). Look for oil tracks starting right at the seals as a clue. Plentiful airflow in this area can blow leaked oil *everywhere!*

Oil on the sides and bottom of the sump can come from the sump seal. Make sure the bolts and nuts are torqued properly.

here. When you get the cylinder off, make sure to check the mating surface on the case for scratches or nicks that might be the actual source of the leak.

If your problem is not with the cylinders but with the case itself, you can start by checking the torque on the outer case bolts (they are ¼-inch bolts) and the bolts that hold the sump and accessory case to the engine. You'll find both bolts and nuts on studs as you work your way around. Truthfully, tightening these bolts beyond torque value isn't going to fix a leak very often—only if they are *really* loose are you going to solve your problem this way. More commonly, you are going to find a gasket that is improperly sealed or one that has finally given way to a latent problem from the build or age. The three-way joint between the case halves and the front center of the sump is a place that oil can often seep, and the only way to fix this is to take everything apart and reseal the engine properly from the start. Pro tip here: Trying to put some sort of sealant over a leaking joint is rarely going to work, and is sort of a last act of desperation. Oil will continue to leak underneath any patch and separate said patch from the engine.

The case halves of a Lycoming are traditionally sealed with a little bit of adhesive to hold two lines of silk thread in place—and that is it! Lycoming does allow a more modern silicone sealant, but most of the big engine builders I have checked with still use silk thread because it works. The sump and accessory case use gaskets, and if you use proper torque, the engine should be tight. Oh, and back to that crankshaft oil seal up front—if

The base of the dipstick tube is a common leak source as no one knows what seal to use—an O-ring or gasket. I've had the best luck with a gasket and form-a-seal plus safety wire (left). Pro tip: If you suddenly have a leak around the oil dipstick on a new engine, check to make sure the dipstick is tight (right). Yep, it's happened. But not too tight: A loose dipstick tube will make a huge mess.

you have a leak from there, you'll have to pull the prop, but the fix is within the realm of a typical homebuilder.

The Worst News

If, after checking everything we've talked about already, you still have a leak you cannot find, you might have a really bad problem—a crack somewhere in your case. Finding such a leak is vitally important if one exists—the last thing you want is the crankcase to fail and send parts of the engine bouncing around inside the cowling. Cracks are best found by using a dye penetration kit, and you'll be thoroughly cleaning the engine again, then running it to try and find the seep. You might well have to remove the baffling to really see all parts of the case, so this is a pretty involved process.

Fortunately, it is also a rare problem—more common on an old case that has seen several overhauls—so keep things in perspective. Yes, case cracks happen, but all of the things we have talked about so far are much more common and therefore more likely. In other words—don't panic! Take your time, completely investigate all possible sources, and get another experienced opinion (or two) before you despair.

Leaks Be Gone

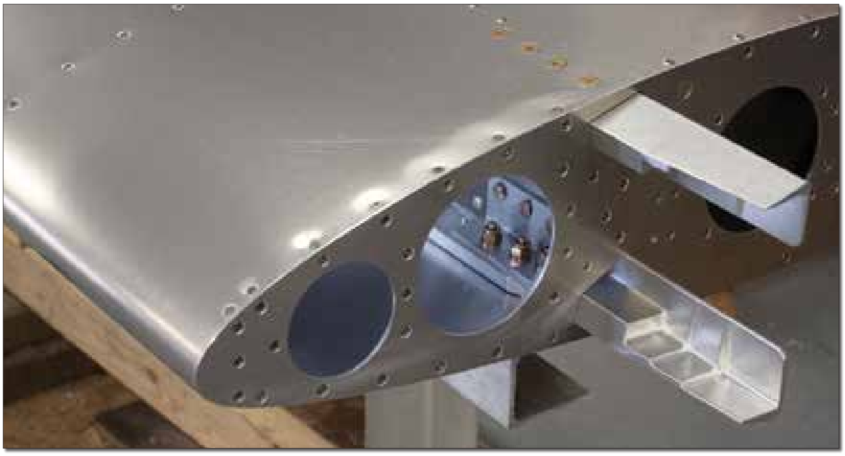
No one likes a messy engine—although a typical oil leak rarely gives a measurable drop on the dipstick, it doesn't take more than a couple of tablespoons of oil to make a real mess! There is nothing as nice as a new motor that leaks nothing at all, and the first time you take your cowl off and find spilled oil can be a real downer. But when that happens, take a look at the points we've outlined and stay on top of it. Fixing a small leak early is far easier than finding one on a completely oil-soaked motor and, no, spilled oil doesn't make anything run better.

The truth is, the basic Lycoming (or clone) design is pretty rugged and well proven—and will continue to run reliably even when it leaks. Nothing is as bad as those old radials. "Hey son, would you fill up the oil, and uh...check the fuel while you're at it?" But it sure is nice when you can clean a few exhaust stains off the belly and not worry about where the oil is coming from. These engines are, in fact, not supposed to leak at all—so when they do, get out the flashlight and wrenches, and stop the seepage! Your plane and engine will be much happier in the long run.

A spine leak between the two case halves is telling you that something is not sealed properly, and the only real solution is splitting the case and having it machined (left). You could slap it back together with new sealant, but once you have it apart, why not go the whole way? A leak around a cylinder base is rare, but when it happens, it can be a pain to fix (right). You have to pull the jug and check for damaged mating surfaces. It's actually more likely the leak is coming from a pushrod tube, but it's worth checking the torque on the cylinder base nuts.

The Watch List

Is anything more disheartening than dropping a piece of hardware in your airframe and not being able to find it? Yes. A loose nut appearing on the cockpit floor while airborne comes to mind. Such sightings can paralyze a body and send a mind racing. On the *Ohcrap* scale, it falls between having the headlights of an oncoming car cast the silhouette of a spider descending from your sun visor onto your retinas and discovering the garage door was left open all night. The search for the nut's proper home will rekindle memories of looking for your adult child's birth certificate. You never had to search for a birth certificate, however, lying upside down in a cockpit while bifocals repeatedly slide onto your forehead. Worse, if you can't determine where the nut came from you will live out your days wondering, worrying.



The dark, cramped interior of a wing's leading edge is one of the preferred habitats for lost nuts and washers.

Such consternation can be avoided, or at least mitigated, by keeping a "watch list." A watch list is a document (and by document I mean 3x5 card), unique from the builder's log or aircraft logbooks, in which items of concern that do not affect the aircraft's airworthiness are recorded. Items like nuts lost inside the airframe. The watch list is not only a record of lost hardware; it is also a place to record items that merit extra scrutiny, such as an assembly that didn't turn out as good as you'd like but didn't meet your strict "do-over" criteria. For instance, if your welded tailwheel pivot seems sound but you question the welding rod you used, add it to the watch list as a reminder to give it a closer inspection during preflight, condition inspections or on the off chance you make a hard landing (unlikely, I know). The watch list is also a good place to note that the left axle is 1° out of alignment, so if you wear through tires quickly you've got a good idea why and so does the aircraft's next owner.

Really Necessary?

Why create a watch list if you are already keeping a builder log and must maintain aircraft logbooks? Great question. The purpose of a builder log is to document that amateurs built at least 51% of an Experimental/Amateur-Built category aircraft. It can be as simple as a photo album showing the airplane's construction in your garage or as involved as a dedicated website documenting each work session in detail. The builder log is made available to the inspector when the aircraft is presented for its airworthiness certificate and there is no requirement to transfer it to subsequent owners of the aircraft (though it's a good idea, particularly if the aircraft hasn't been licensed).

Builder logs are never carried in the aircraft. Recording lost hardware in a builder log is a sure way to bury that useful information forever.

Airframe, engine and propeller logs are records that the inspections required to maintain (or reestablish) an aircraft's airworthiness have been performed. Required entries include the completion of Condition Inspections and compliance with Airworthiness Directives and Service Bulletins. These logs are also used to record the completion of maintenance. They become a permanent part of the aircraft's documentation and pass from owner to owner, but are seldom kept in the aircraft. Losing a cotter pin in the aft fuselage is not an event to record in the aircraft's logbooks. Thus, the watch list. Unlike a builder log and the aircraft logs, a watch list should be kept in the aircraft where it is convenient to reference at the hangar, on a flight away from home or even in the air should paranoia strike hard.

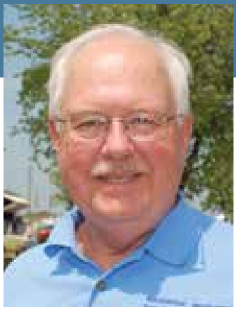
Kerry Fores

Kerry Fores grew up jumping the airport fence in Oshkosh, Wisconsin. He wanted to build an airplane in 10th-grade woodshop but was asked to choose a smaller project. In 1998, unconstrained by teachers, Kerry scratch built a Sonex he polished and named Metal Illness. *It was awarded Plans Built Champion at AirVenture 2006. Kerry is on the web at* www.thelifeofdanger.com.

The watch list is a living document begun as needed during aircraft construction and revised as appropriate for the life of the airframe. New entries are made as necessary and old entries are deleted when they no longer apply. Noting the recapture of a wayward nut is as important as recording its loss in the first place. If you fail to record that an AN365-1032 nut you recorded as lost cried "uncle" and crawled out from its hiding spot after a Lomcovák, the appearance of another one can falsely signal the surrender of the nut you lost. However, if you've recorded that a lost nut was found, the appearance of another nut gives you reason to ground the airplane and investigate. Also, if you fail to record that a missing nut has been found, a future owner of the airplane can mistake a free-ranging nut for the one you listed missing and continue to fly with a safety issue looming.

Let me also define what a watch list isn't. It is *not* a substitute for quality workmanship, proper maintenance or a genuine effort to prevent having to have a watch list in the first place. It is not a place to record design modifications. Design modifications (your one-of-a-kind electric flap installation) and assembly deviations (doubling the number of rivets in the wing walk) should be noted on the assembly plans or in the construction manual. If, however, you lose a wire connector in the wing root while wiring the flap motor, record *that* on the watch list.

I know what it is like to paste a washer to your fingertip with spit and blindly guide it onto a bolt inside the wing. The odds of dropping it are great and the odds of finding it decrease in lockstep with your patience. Throw your best effort into finding it and if you can't, record its disappearance on a watch list. In the future, if a washer falls to the floor while removing the wing's inspection cover, learning that a similar washer was lost while attaching the aileron pushrods to the bellcrank will be akin to finding nothing missing from your garage after it was left open all night. There is never relief from seeing a spider in your car because you have to ask: Are there others?



MAINTENANCE MATTERS

Yearly Condition Inspection, Part I

If you own a Cessna or other certificated airplane, you need to get an annual inspection every year. If you own an Experimental/Amateur-Built airplane, you will need a yearly condition inspection. The difference is that certificated airplanes must be shown to be in compliance with their type certificates—Experimentals do not have type certificates, so their condition inspections are somewhat different.

Use a checklist when performing your condition inspection. Customize it to fit your airplane and add items as needed. Make note of things that need to be fixed. Once complete hang onto the checklist for future reference.

An Experimental must be found to be in a "condition for safe operation." There is no prescribed standard for making that determination other than Part 43, appendix D of the FARs. That means that you, as the holder of a Repairman Certificate or your A&P mechanic, must make that call. This places an extra responsibility on aircraft owners to determine what is safe, but the FAA has not left you without guidance. There is a lot of good information in Part 43, Appendix D. Let's take a look at how that can help you perform a good condition inspection.

First, who can perform a yearly condition inspection? If you built your airplane and received a Repairman Certificate from the FAA, you are eligible to perform this inspection. If you built your plane but never got the Repairman Certificate, why not? Get down to your local FAA FSDO office with your airplane paperwork, your builder's log with photos (the FAA guys love to see photos) and a photo ID to apply for one right now. If you are not the builder, you will need to find a licensed A&P mechanic to perform and sign off your inspection. Unlike a certificated airplane owner, you do not need an A&P with Inspection Authorization (IA). Even if you have a Repairman Certificate, if this is your first time performing a yearly condition inspection, it's a good idea to seek out the assistance of someone with experience to guide you through the process. Experimental-Light Sport (E-LSA) owners have a separate set of rules to deal with, so be sure to check if this applies to you.

The first question many new owners have is, what do I inspect? To find the answer, look at FAR Part 43, Appendix D. The FAA provides a list of what it wants to see checked, and this is where you can find it. When you are finished with your inspection, you will attest to covering the items on this list with the following statement:

I certify that this aircraft has been inspected on (date) in accordance with the scope and detail of 14CFR Part 43, Appendix D, and was found it to be in a condition for safe operation.

The entry will include the aircraft's total time in service and the name, signature, certificate number and type of certificate held by the person performing the inspection. If you can't find this article when it is time to do your inspection, look for the required language in your operating limitations.

Dave Prizio

Dave Prizio has been plying the skies of the L.A. basin and beyond since 1973. Born into a family of builders, it was only natural that he would make his living as a contractor and spend his leisure time building airplanes. He has completed three—a GlaStar, a Glasair Sportsman and a Texas Sport Cub—and is helping a friend build an RV-8. Dave shares his love of aviation with others by flying Young Eagles or volunteering as an EAA Technical Counselor. He is also an A&P mechanic, Designated Airworthiness Representative (DAR), was a member of the EAA Homebuilt Aircraft Council for six years, and is the recipient of the Tony Bingelis award.

The black rings around these rivets mean that they are loose. This is what is meant by smoking rivets. Often, they will also leave a black trail extending rearward.

Before you get started, you should be sure all of your paperwork is in order. You need to have an airworthiness certificate *displayed* inside your aircraft. You also need to have the registration in the plane, but it does not need to be displayed. Along with the airworthiness certificate, you need to have your operating limitations and your weight and balance. Of course, these items need to match up with the data plate. If anything is missing or awry, you need to fix it.

The inspection begins by cleaning the aircraft inside and out, including the engine compartment and engine. If it isn't clean, you can't really see what kind of shape it is in. The regulations cover the inspection process step by step. There isn't a lot of detail, but it shouldn't be hard to create a detailed checklist from the guidelines provided. We will follow the scope and language of Part 43, Appendix D. Words in italics are taken directly from the FAA regulation.

Fuselage and Hull

(1) Inspect the fabric and skin for signs of deterioration, distortion, other evidence of failure and defective or insecure attachment of fittings. With fabric aircraft, this means a thorough inspection of all fabric-covered surfaces with further testing in any questionable areas. Expect to see the first signs of trouble on the tops of wings and fuselage—areas exposed to the sun. For metal, cracking and corrosion will get most of your attention, but also be on the lookout for missing fasteners or smoking rivets. Composite airplanes need to be checked for cracking and delamination.

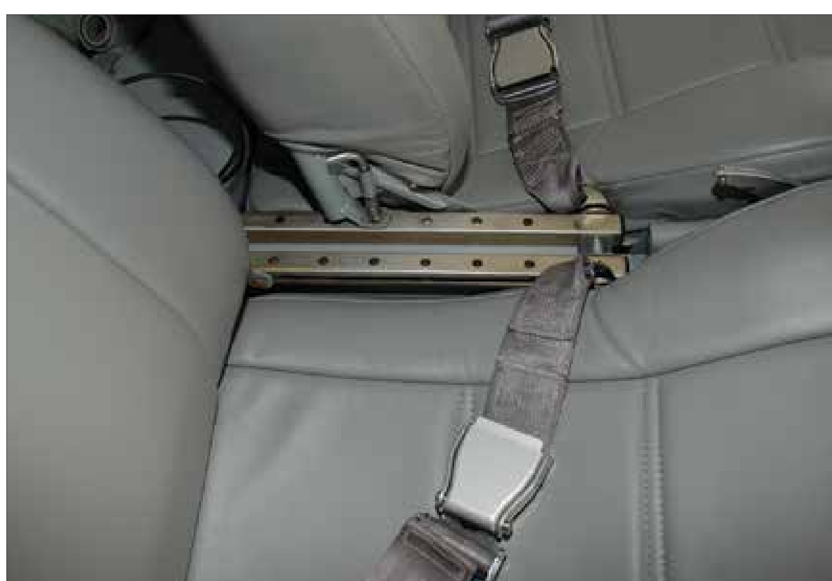
(2) Inspect systems and components for improper installation, apparent defects and unsatisfactory operation. Anything attached to or a part of the fuselage is covered here. This could include cabin and baggage doors, static ports, fuel drains, antennas, fairings, control cables and flying wires or other items. These will vary from plane to plane, and some items may be covered in other sections. Just be sure all items are covered somewhere. Every item should be in good condition and functioning properly.

(3) Envelope, gas bags, ballast tanks and related parts—for poor condition. Most aircraft do not have these items, but if yours does it is important to inspect them carefully.

Cabin and Cockpit

(1) Generally—for uncleanliness and loose equipment that might foul the controls. A clean plane is a happy plane. If it isn't clean, it can't really be properly inspected. Beyond that foreign debris, "spare" parts, tools, loose wires and other such things can lodge in controls and lead to catastrophic problems. As a rule, keep a careful account of all tools used and make sure you get them all back when you are finished. A missing tool or small part could jam your controls. Even a missing washer needs to be tracked down and removed. The temptation to let it go can be strong, but it should be resisted.

(2) Seats and safety belts—for poor condition and apparent defects. Obviously, seat belts and shoulder harnesses are important. Replace them if there is any doubt about their condition. Check bolts that secure them to the airframe and replace as needed. If you don't have shoulder harnesses, this would be a



Check the condition of all seat belts and related hardware. Stitching should be tight, cloth should be undamaged, all hardware should be in place and in good condition and latches should work easily and hold securely.

Photos: Dave Prizio

Check cable tension on all cables with a proper tester (left). Be sure to use the correct scale for the diameter of your cable. Check all engine control linkages for cotter pins (right) and free movement throughout the range of travel.

good time to install them. The life they save could be your own.

(3) Windows and windshields—for deterioration and breakage. Windows and windshields should be free of cracks, excessive crazing and defects that would impair your ability to see. Cracks that do not impair vision can be stop drilled to keep them from spreading. An ounce of prevention is worth a pound of cure here. Be sure when installing these items that they are free of nicks and stress, and be sure to only use clean towels and proper solutions when cleaning. No paper towels, please, and no wiping dry windows.

(4) Instruments—for poor condition, mounting, marking and (where practicable) improper operation. Instruments that don't work need to be placarded as such, but better yet just fix them or remove them. Anything that is required will obviously need to be repaired or replaced. This category is very specific to your airplane since there are an almost infinite number of possible instrument combinations available. Check your tachometer with a strobe-type instrument. If you don't own or have access to one, this is a good thing for an EAA chapter to buy and share among its members.

(5) Flight and engine controls—for improper installation and improper operation. When you open up all those inspection holes in your wings, you are making it possible to see all the rod ends, cables and bellcranks that make up the flight control system. Make sure everything is secure with cotter pins in place and cable adjusters safety wired or with clips installed. Verify proper travel of all flight controls and check for free and correct movement. If you have removed any flight controls or cables for any reason, triple check for correct movement. An improperly rigged plane may be impossible to fly. Be sure that there are no signs of chafing on any control cables or tubes. Replace them if there are. Check cable tension with a gauge. Be sure to allow for the current temperature when interpreting the tension readings.

Similarly, engine controls should be checked for free and correct movement. The throttle, mixture and prop controls should move through their entire ranges of motion with a little cushion at the maximum point. The mixture control should shut off fuel and stop the engine when pulled all the way out. Correct any deficiencies and replace parts as needed.

(6) Batteries—for improper installation and improper charge. Make sure all battery and starter cables are clean and free of corrosion. Many hard-starting problems can be traced to poor cable maintenance. In an age when batteries seem to be getting smaller and our dependence on electrical power is getting greater, the battery becomes even more important. Get a battery-condition tester (load tester) and use it. These can be bought at Harbor Freight Tools for around $55. There is no way to tell how much power your battery really holds without such a tester. If you fly at night or in instrument conditions, this is really important. Your battery may start your plane just fine, but its amp-hour capacity may be much less than you think. Having your electrical system

Engine controls should work freely and have a small amount of cushion in the travel. In other words, at full throttle the control knob should not quite go all the way to the end of its travel .

Use a battery load tester to check out the condition of your battery. This one could be better, but it is still acceptable. These testers can be bought at Harbor Freight Tools for around $55. Be sure cables and connections are in good shape, too.

die 15 minutes after your alternator fails is not going to be a pleasant experience if you are in the dark or in the soup.

(7) All systems—for improper installation, poor general condition, apparent and obvious defects and insecurity of attachment. This is a catchall for anything on your plane that hasn't been covered somewhere else. If it's on your plane, it needs to be checked to be sure it works properly and is likely to continue working properly. This will vary from one aircraft to the next, so you will need to create a checklist with yours in mind.

Engine and Engine Compartment

(1) Engine section—for visual evidence of excessive oil, fuel, or hydraulic leaks and sources of such leaks. This doesn't say that you have to fix every little leak you see, but it does mean that you need to look into the cause of those leaks and fix any that pose a hazard. Leaking oil, fuel or hydraulic fluid can compromise the function of vital equipment. Leaking fluids can also be a fire hazard. Tracking down leaks can be frustrating, but it is important.

(2) Studs and nuts—for improper torquing and obvious defects. Check exhaust and intake flanges for proper tightness. Be sure to use the correct, verified torque numbers. Engine manufacturers don't always make it easy to find this information, but it is always there somewhere. If in doubt, call the technical support phone number and ask. Re-torque engine case bolts if there is any sign of leaking. Check alternator belt tightness as per manufacturer's instructions. It is always good to just go around the engine and check everything for general tightness just in case. Any problem areas need to be examined in more detail. By the way, right before your condition inspection is a good time to have your torque wrench calibrated.

(3) Internal engine—for cylinder compression and for metal particles or foreign matter on screens and sump drain plugs. Drain the oil and remove the filter and sump screen. Check for metal and retain a sample for oil analysis. This includes cutting open the filter and checking for metal there, too. This is your best window into the internal condition of your engine. If you find metal, consult the engine manufacturer's literature for allowable amounts and types. Take corrective action for anything that falls outside of acceptable parameters. Note that these will vary from one engine manufacturer to another. For example, metal that is perfectly acceptable to Lycoming could be reason for tearing down a Rotax engine.

A differential compression test should also be performed during your condition inspection. Be sure to get the proper tester—there are different sizes of control orifice, one for engines with bores less than 5 inches and another for larger-than-5-inch bores—and some experienced help if you haven't done this test before. It isn't hard to do, but there are definitely right and wrong ways to do it. If your compression is low, again, you need to consult the engine manufacturer's

Inspect the sump screen when changing the oil during a condition inspection (left). Any metal pieces found in the screen need further investigation. The screen is located at the rear of the sump on the bottom of the engine. Be sure to cut open your oil filter and inspect the media at each oil change (right). Each engine manufacturer has guidelines for how much metal is acceptable to find at such an inspection.

An easy way to see if the engine mounts are sagging is to check the alignment of the spinner and the cowl (left). This spinner is right where it should be. Check exhaust nuts for proper tightness (right). Use a torque wrench to avoid overtightening the nuts.

publications to see how to interpret the readings. Lycoming, Continental and Rotax all have different ideas about what is and is not an acceptable compression reading and what you should do if one or more cylinders test low.

I would recommend adding a borescope examination to your engine inspection routine. Borescopes are now very reasonably priced, and they can reveal many things that a compression test cannot.

(4) Engine mount—for cracks, looseness of mounting and looseness of engine to mount. Cracks in the engine mount tubes are obviously unacceptable and must be repaired, as are any loose nuts or bolts, but less obvious problems can also arise. Check for chafing wherever anything is attached to or is near the engine mount tubes. Zip ties are especially problematic in this regard. Replace them with cushioned Adel clamps wherever possible. Engine mount bushings can also sag with age. Shimming can cure some sagging but at some point they need to be replaced. A prop spinner that has shifted downward in relation to the cowl is a good tipoff that the bushings are sagging.

(5) Flexible vibration dampeners—for poor condition and deterioration. These are not common but their condition is very important where they do occur. In this category we might also include Rotax drive clutches and prop speed reduction units.

(6) Engine controls—for defects, improper travel and improper safetying. Engine controls are not usually much trouble, but they are very important so test them for proper function and security. Make sure all required safety wire and cotter pins are in place.

(7) Lines, hoses and clamps—for leaks, improper condition and looseness. Carefully inspect fuel and oil lines for integrity and security. Note that firesleeve can conceal small leaks, so look for any discoloration that may indicate a leak inside. SCAT ducts also need to be checked for wear, security of their clamps and heat damage. Zip ties can cut through SCAT and exhaust-pipe heat can cause rapid deterioration. Look them over carefully; when in doubt throw them out and replace them with new material. Rubber fuel and oil lines, even those pretty stainless steel-covered ones, should be considered for replacement after 10 years.

(8) Exhaust stacks—for cracks, defects and improper attachment. Exhaust leaks at the cylinder head flanges can quickly damage cylinder heads. Always check flange bolts for proper torque and

Perform a differential compression test at each condition inspection (left). It is safer if you have a friend hang onto the prop just in case it tries to move during the test. The exception to that advice is if you have a Rotax engine. Never hold the prop during a compression test with a Rotax. Be sure to stand clear of the prop when performing a compression test on a Rotax 912 or 914 engine (right). The gear reduction unit adds torque to the prop that makes it all but impossible to hold.

Properly torque and use anti-seize on your new or newly cleaned spark plugs when you install them (left). Consult the engine maker for the proper plugs, torque and anti-seize for your engine. Check the magneto timing at each condition inspection (right). You will need a special magneto timing device to do this.

replace gaskets and lock nuts at any sign of trouble. Other cracks also need immediate attention since they only get worse the longer they remain. Remove any shrouds over mufflers to look for leaks, especially when dealing with cabin heat system components. Exhaust leaks are serious, so don't cut corners here.

(9) Accessories—for apparent defects in security of mounting. Here we can include alternators, vacuum pumps, starters and backup systems of any kind. This will vary from one plane to the next, so you will have to devise your own checklist to cover all items.

(10) All systems—for improper installation, poor general condition, defects and insecure attachment. This is a catchall for anything you missed in another category. Develop a list to fit your plane.

(11) Cowling—for cracks and defects. Cowling cracks or heat damage need to be repaired whenever they occur. Sometimes a modification to the cowl or the installation of a heat shield will be required. Cowl fasteners also fall into this category. This is probably a good place to include engine baffles, too. Good baffles and seals work together with a sound engine cowl to efficiently cool your engine. It is worth an investment of time to get these things into good shape.

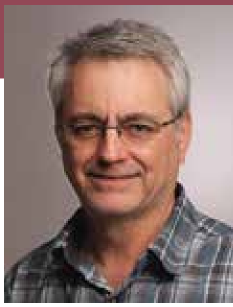
Where You Can Find a Detailed Checklist

Most kit manufacturers do not provide condition inspection checklists to their customers, arguably because every plane is different to some extent. Liability concerns also undoubtedly play a part. However, many manufacturers will supply a final assembly checklist that can be adapted to a condition inspection checklist. Builder groups and forums are probably the best place to look for time-tested checklists. Builders who have been flying for a few years will likely have pretty good checklists that they will share for the asking. Even a checklist for another type of airplane can serve as a model. Ask around at your EAA chapter and you are sure to turn up something you can use.

With all that said, be sure not to just use any checklist without carefully matching it up to your airplane. Different accessories or avionics will require different checklist items, as will any custom modifications you may have made. The FAA requirements need to be met in any case, so be sure to check your list against Part 43, Appendix D. For inspection and service requirements that apply to any manufactured item such as an engine, prop or avionics, be sure to check with the manufacturer of that item for guidance. Lycoming, Continental, Rotax and Hartzell, just to name a few, have extensive information available to owners and maintenance technicians regarding their products. They also have technical support staff to help if you need it. No question is a dumb question if it saves you from making an expensive mistake.

Next time we will look at the rest of the airplane, including the prop, wings, empennage, landing gear, avionics and miscellaneous items. We will also visit the subjects of service bulletins and airworthiness directives. ✈

These baffles are in good shape but the seals look like they are getting worn out. A good seal between the baffles and the cowl is vital to keep engine temperatures in line.



HOME SHOP MACHINIST

Billet or Weldment With Off-Axis Turning?

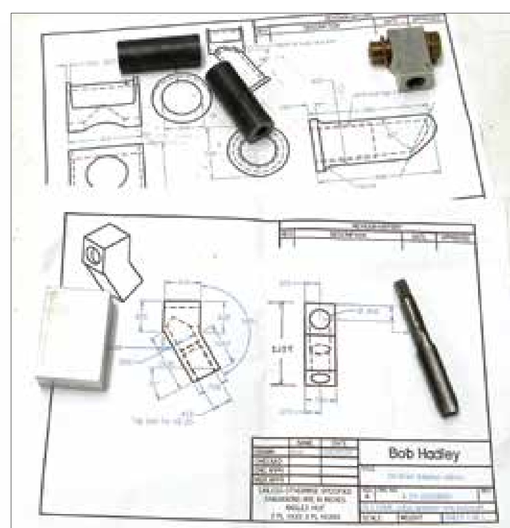
People tend to design around their particular expertise. A machinist will design based on machining parts out of solid billet, a welder will design for a weldment, and the guy with a foundry will design for castings. The point being, designing is often like driving across town. Very rarely is there only one way to get from point A to point B.

This month's project illustrates two approaches to the same end: an angled adapter for a Curtis quick-change oil valve for my new Jabiru engine. The standard 90° Curtis adapter for the Jabiru didn't provide enough clearance for my particular installation. The April 2017 issue of KITPLANES® covered a solution for making an elbow to fit the same drain valve for my original engine. While that worked fine, it required getting my hand pretty close to the exhaust pipe to twist the valve open. The new engine offered the chance to rethink the idea. I decided a version based on the Curtis design, but with a different angle, would make the valve more accessible.

The Curtis elbow adapter is nicely machined from billet aluminum (though I have seen an older, identical elbow made from brass), so the natural choice was to make the new one out of the same material.

But suppose it's a Friday night and you want to get this made on Saturday so you can be in the air on Sunday. You've rummaged through your material supply, including cutoffs and leftovers from other projects. All you have is some ¾-inch steel bar stock. But you also have a TIG welding machine. Can this part be a weldment? The part is small, so weight is not a factor. It's not subject to any unusual stress or structural loading of any kind. All things considered, there's no reason against a weldment as a viable option.

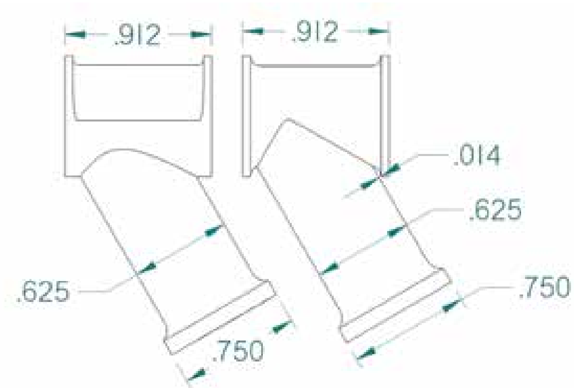
Two parts with identical function made with different materials and techniques. On the left is a billet-machined oil-drain angle adapter, and on the right is a welded-steel adapter. The drain ports of both were threaded ½-20 TPI for a Jabiru-compatible Curtis quick-drain valve (Curtis part number CCA-2460).



The original Curtis valve and adapter (left) and design drawings (right). Visit *www.kitplanes.com/angled-adapter* to view the drawings in greater detail.

Bob Hadley

Bob Hadley is the R&D manager for a California-based consumer products company. He holds a Sport Pilot license and a Light Sport Repairman-Airplane (LSRM-A) certificate.



The drawing on the left shows the correct way to design a weldment. The weldment depicted on the right doesn't have enough room to TIG weld around the flanges without melting—and destroying—the flange. The independent four-jaw chuck in the photo was used to turn the off-axis part. To set the distance off axis, the part must first be adjusted for zero runout using a dial indicator, then two opposing jaws are adjusted to achieve the desired offset. The off-axis amount for the cross tube for this project was 0.055 inch (shown on the dial.)

The spinning part will produce a ghost image.

The off-axis turning ready for parting off (left). The large-radius tool was made by hand grinding a high-speed steel tool bit (see "Daily Grind," September 2017). For parting off and facing to the final length, the 4-jaw independent chuck was exchanged for the normal 3-jaw, self-centering, chuck. A ⅜-inch hole was drilled in the cross tube exactly opposite the off-axis feature (right).

The weldment design still required a bit of machining, mostly to remove excess material (i.e., weight). Note especially how the drain tube (the angled extension) is concentrically turned to ⅝-inch diameter, while leaving a ¾-inch face flange to insure a proper seat for the MS 35769-9 gasket.

When I made my initial sketch, I had the cross tube slimmed down in a similar manner: a ⅝-inch-diameter center section with ¾-inch flanges at each end for sealing. However, my experience designing parts for welding immediately told me that was not going to work. TIG welding into those tight gaps would burn through and ruin the flanges.

My solution was to eliminate the flanges, but lighten the cross tube using a lathe trick called off-axis turning. While it doesn't remove as much weight, it makes for a cool-looking part and solves the problem of trying to weld around a flange.

The Off-Axis Experience

Your first off-axis turning experience will be just that: an experience. The very nature of this type of turning seems unnatural because you are—on purpose—setting up the lathe to be out of balance. How much out of balance depends on the size, weight and how far off-axis you set the part. A small part (like the one shown) in a heavy lathe may not vibrate much, if at all. But the same part in a small bench lathe might shake like a bad California earthquake.

When making an off-axis turning, start with the lathe rpm at its slowest setting and gradually increase the rpm. If the

Photos: Bob Hadley

lathe starts to shake before you reach the normal rpm for turning (500 to 800 rpm for a small part like this one), then back off.

The tool will be making an "interrupted cut," which means, for each rotation of the spindle, the tool will be cutting only the offset side. This tends to freak out some people, but once you get used to it, it's no big deal. The secret is to ease the tool into the spinning part and take light cuts. If you get too aggressive, you will know it from the sound of the tool slamming into the part. You want more of a "whoosh-whoosh-whoosh" sound of chips coming off the tool than a "bang-bang-bang" sound of the tool crashing into the part.

To make the *drain tube* (left) the end was faced square, then through-drilled using a 29/64-inch twist bit (the tap size for ½-inch x 20 TPI). With the lathe *off,* but using the chuck to hold the workpiece (right), the drainpipe was tapped to a depth of ¾ inch.

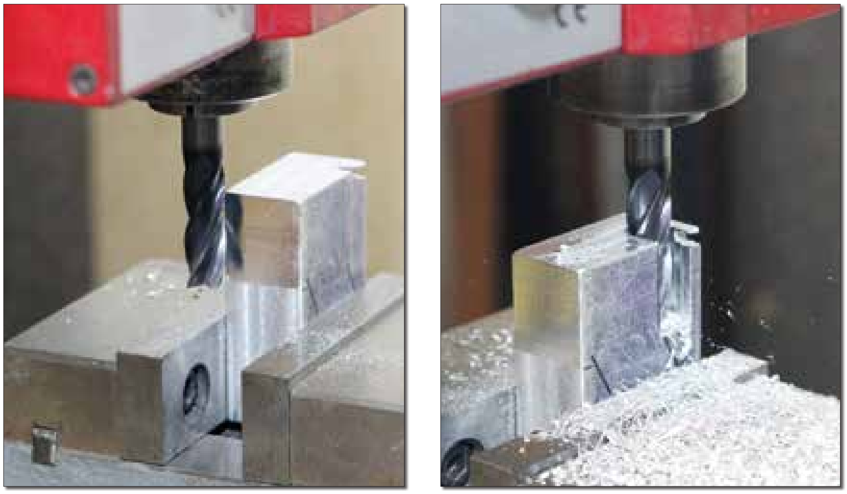
Slimming the outside diameter (OD) of the drain tube down to 0.625 inch was done in a series of steps (left). The flange was initially left wider than the design callout to allow for the radius. The width and radius of the flange were made using the same hand-ground high-speed steel tool bit used for the off-axis turning (center). With the radius and flange machined, the remaining length was repositioned in the chuck and turned to match the previously turned 0.625-inch diameter. The next step was to part off the excess in preparation for being fishmouthed on the mill (right).

To hold the drainpipe for milling the fishmouth, it was installed backwards in a ⅜-inch 5C collet and then secured in a 5C indexer (left). The indexer was then clamped in the mill vise at 30° from vertical. The milling cutter is ¾-inch diameter to match the cross tube diameter. After polishing with a Scotch-Brite pad (center), the two tubes were welded together (right).

The Billet Adapter

The billet adapter was in fact easier to make, but the faces *must* be square to the holes to assure they won't leak. A good machinist square is as important to this project as the milling machine and drill press.

A few closing thoughts on Curtis drain valves. They are, in my opinion, a must-have accessory for anyone who does their own oil changes. You simply push a 3/8-inch rubber hose on to the outlet pipe, stick the other end in your drain pan and twist the valve a quarter turn to open. No oil dribbling out of the pan, no oil on your hands and no oil on the floor! Curtis makes a wide range of valves for almost any application, and while their elbow adapter didn't work for me, it was an easy job to make one and a good example of the utility of the home shop when it comes to customizing your airplane. That's it for this month; time to get out in the shop and make some chips! ✈



The two parallel faces and top were milled square to each other to establish reference planes for the rest of the machining operations.

A protractor and machinist square were used to set up the remaining mill work.

Drilling (left) and tapping (right) the drain hole.

Using 400- to 600-grit wet/dry sandpaper and a granite surface plate, the faces were lapped smooth and flat using a figure-8 motion.

Test fitting the weldment and Curtis drain valve to the Jabiru sump. For corrosion resistance the steel adapter was clear coated with an acrylic spray and the aluminum adapter was treated with an alodine dip.

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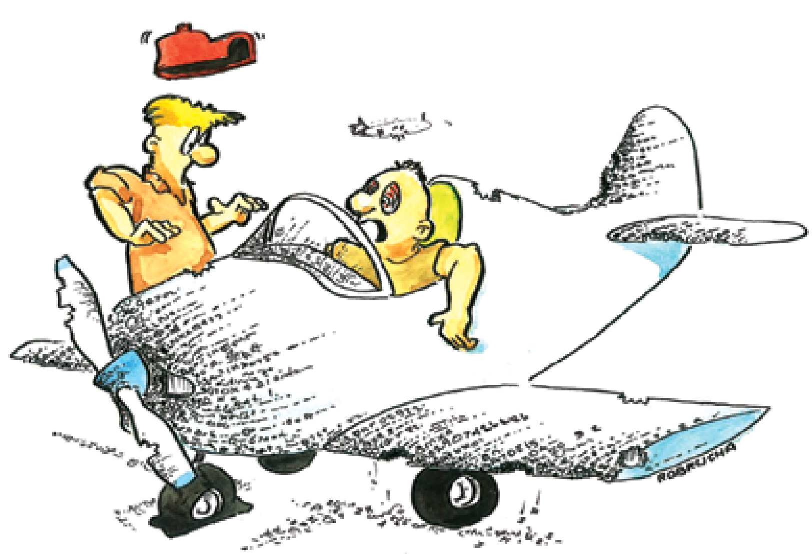
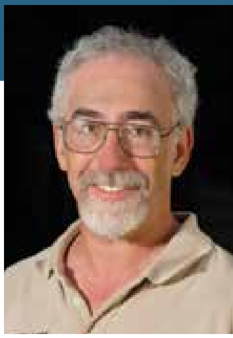


WHEW! I JUST FLEW THROUGH AN I-CLOUD AND WAS ATTACKED BY AN ANTI-VIRUS!



Design Process: Planform Effects on Span Loading and Drag

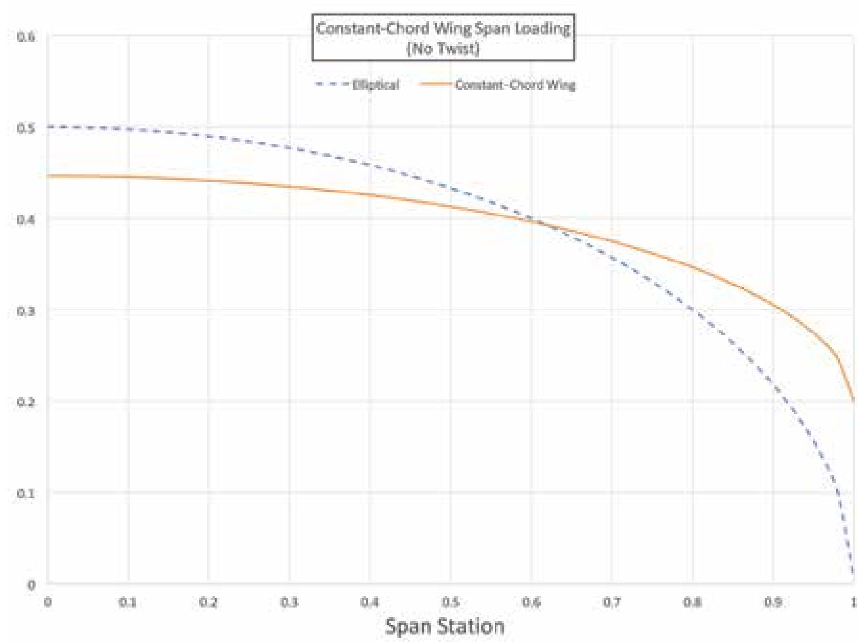


Figure 1: Note that the loading of this constant-chord wing is far from an elliptical wing. Moreover, the loading is shifted outboard significantly.

Last month we started our discussion of wing planforms with a look at the various planform shapes in use. We now turn our attention to the effects of differing planforms on span loading and drag.

When choosing a planform, the designer must consider many factors. The goal is to come up with a wing design that provides acceptable aerodynamic performance, has good flying qualities, meets weight, strength and cost requirements, and can be fabricated with available technology. Another important consideration is drag.

The primary drag component affected by planform is induced drag, otherwise known as drag due to lift. We discussed the effect of span on induced drag in some detail in the July 2020 issue. For this month, just remember that induced drag is inversely proportional to wingspan squared. This means that a planform concept that allows greater span will probably reduce induced drag.

It's only "probably" because of the effect of the shape on span loading. Induced drag is a function of both wingspan and the spanwise distribution of lift along the wing.

Span loading determines the second factor affecting induced drag: span efficiency. Span efficiency is a measure of how much induced drag a configuration produces relative to the induced drag of an ideal configuration of the same span generating the same lift. It is denoted by a number called the Oswald efficiency factor, which is represented in equations by the letter E and expresses the ratio of ideal induced drag to actual induced drag.

It is important to understand that this discussion is for wings of the same span carrying the same lift.

A "perfect" wing has an E of 1.0. As E goes down, induced drag goes up by a factor of 1/E. For example, a wing with a span efficiency of 85% would have 1/0.85 or 1.176 times the induced drag of a perfect wing.

Classical theory tells us that an ideal wing has an elliptical-shaped spanwise distribution of lift. Accordingly, E=1.0 represents a wing with an elliptical span loading.

The more the span load deviates from elliptical, the higher the induced drag. In general, a wing that is more tip-loaded than elliptical will have higher induced drag than a wing that is more root-loaded than elliptical, although it will have higher induced drag than a wing with a truly elliptical span load.

Recently a few planform concepts have demonstrated E > 1, but for the moment we will leave them for consideration another time.

There are also several interesting concepts that trade the loss of span efficiency of the proper non-elliptic span loading for structural advantage that allow span to increase, but for now we will consider the effect of planform shape on span loading and induced drag at constant span and lift to understand the purely aerodynamic effect. We will discuss the interplay between

Barnaby Wainfan

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planform, span load and structural weight in a future article.

There have been a few airplane types built with wings with elliptical planforms to minimize induced drag. The most famous of these is the WW-II Spitfire fighter.

Elliptical wings are rare for several good reasons. The most important is that they are difficult and complicated to build. Not only is every rib different, but the wing skins have compound curvature. Likewise, the spar caps will be curved, and there are no straight element lines on the surface that form convenient control-surface breaks.

Although elliptical wings have high span efficiency and can be quite beautiful, the induced drag advantage of the shape is not large enough to overcome the other disadvantages of the configuration. While the wing is not the complete cause, it's interesting to note that the Spitfire took 13,000 labor hours to build, while the contemporary Hurricane took 5200. For contrast, look at WW-II fighters designed with mass production in mind: The Messerschmitt Bf 109 took 4000 hours to build, and the North American P-51 got down to 2500 in full-rate mass production.

For producibility reasons the vast majority of wings are designed so that the skins are simple ruled surfaces. This means that the planform will be composed of straight-line segments. The wing will either be rectangular (constant chord), trapezoidal (straight-tapered) or a combination of the two (compound taper).

Let's take a look at how these planform concepts affect span loading. Note for this discussion that we are looking at wings with no twist. Twist can be used to adjust the span loading, but first we need to understand what the planform itself is doing.

In today's world, there are multiple computer codes that can be used to calculate wing aerodynamics. Fortunately, for those who do not have access to such things, there is a simple approximate method developed years ago that produces reasonably accurate results. This method, devised by Oskar Schrenk, holds that the span loading of a wing is the average of an elliptical loading, and it's a loading that mimics the planform shape directly. The "Schrenk approximation" is still widely used for preliminary structural design for light aircraft. Details can be found here:

NACA-TM-948, "A Simple Approximation Method for Obtaining the Spanwise Lift Distribution": O Schrenk, 1940 *(https://tinyurl.com/spanwise-lift).*

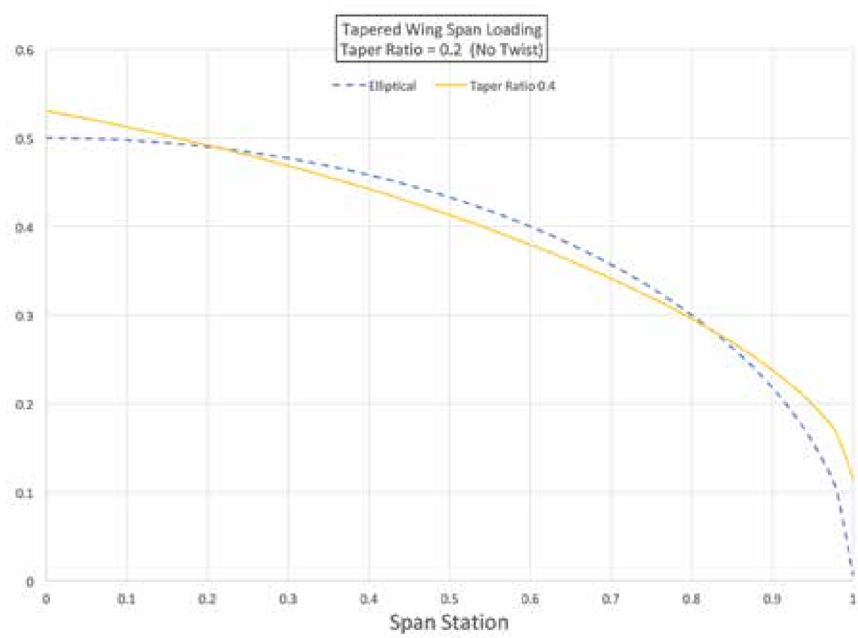


Figure 2: The span loading of this tapered wing is much closer to elliptical than a constant-chord wing. It is also more root-loaded than either an elliptical or constant-chord wing.

Constant Chord

First, let's look at a constant-chord wing. Constant-chord wings are quite common because they are relatively simpler and less expensive to tool and build than other types, particularly for sheet-metal structures. There are penalties for this cost savings, however.

The span loading of a constant-chord wing, compared to an elliptical distribution with the same total lift, is shown in Figure 1. Note that the loading of this wing is quite far from elliptical. Moreover, the loading is shifted outboard significantly.

This has two effects: First, it will hurt span efficiency and increase induced drag. A second effect, which will be discussed in more detail in a future article, is that the centroid of the wing lift is also significantly outboard of what it would be if the loading were elliptical. This means that the bending moment is at the wing root, and the stresses in the spar will be increased accordingly.

Straight Taper

A second very common planform is the straight-tapered wing. The amount of taper is defined by the "taper ratio," which is tip chord divided by root chord. This can be confusing since the more tapered a wing is, the lower the taper ratio. Accordingly, for example, a wing with a tip chord half as long as the root chord has a taper ratio of 0.5, while a constant-chord wing has a taper ratio of 1.0.

The span loading for a wing with a taper ratio of 0.4 is shown in Figure 2. Note that even though the planform is a simple trapezoid, the span loading is much closer to elliptical than that of the constant-chord wing. Accordingly, it will have a higher span efficiency and lower induced drag than the constant-chord wing shown above.

The tapered wing is more root-loaded than either the elliptical or constant-chord wing. This shifts the centroid of the lift inboard and reduces the bending moment at the wing root.

Charts: Barnaby Wainfan

Compound Taper

There are a wide variety of compound-tapered planforms, but the most common is a wing with a constant-chord center section and tapered outer panels. This is an attractive approach for low-wing airplanes in particular since it makes the spar-fuselage carry-through in the center section straight and allows the center section to be permanently affixed to the fuselage, with attach fittings to hold on the outer panels where the spars change direction to generate the taper. If the airplane has wing-mounted landing gear, this has the added advantage of making it possible to remove the outer wings with the airplane standing on its gear.

Figure 3 shows the span load for a compound-taper wing that is constant-chord to one-half span and tapered outboard of that.

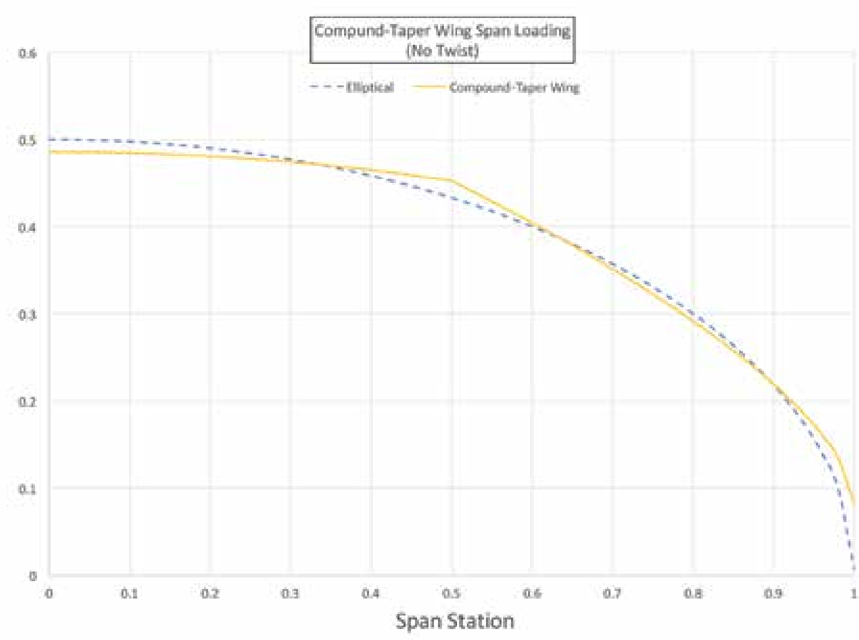
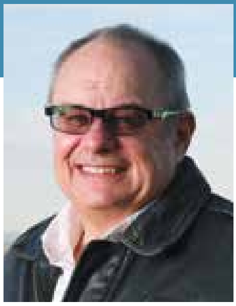


Figure 3: The span load of a compound-taper wing that is constant-chord to one-half span and tapered outboard of that. Note that the span loading is very close to an elliptical wing.

The important thing to note here is that this relatively simple planform concept generates a span loading that is very close to elliptical. It will have a high span efficiency and, as we have seen, has some configuration integration advantages.

All wing designs involve a trade-off between aerodynamics, ease of manufacture and structural weight. Next month we will continue our discussion with a look at how planform affects structure and weight. ✈



Airpark Living

Since the very discovery that such a thing existed, I, like many other pilots, have dreamed of airpark living. For the purposes of this column, I will define "airpark" as a residence associated with a runway—or more than one runway, if you're really lucky. Airparks exist in a wide variety of types, from farms and ranches with perhaps a simple dirt or grass strip to vast communities of hundreds of individual habitations and municipal airport-level facilities, including full-service FBOs and even instrument approaches. Some are geared toward full-time living and others more as vacation getaways. Many are a combination of the two.

Airparks and Experimental/Amateur-Built aircraft are not inherently linked, but are wonderfully well suited to each other. Nothing beats the convenience and efficiency of having your beloved project close by. (Projects may be flying, but they are never completely finished.) It is even better still when an enthusiast is immersed in a close community of like-minded individuals from which to garner support, inspiration, advice, tools, supplies, refrigerator contents… whatever. No wonder, then, that a large percentage of E/A-B aircraft are built and kept at airparks and that airpark marketers and airpark-oriented venders are abundant at Oshkosh and similar events.

Individual as You Are

The individual desires and requirements for potential airpark residents are as varied as the properties themselves. As just one example, I will share some of the journey that my wife and I have taken from being shoppers, buyers, builders and then residents.

One of the advantages of working as an airline pilot is that one can live pretty much anywhere. Pilots are based in a domicile that they are awarded by seniority. Pilots who live somewhere where they can't drive to work are considered "commuters." Even though it is estimated that roughly half of all airline pilots commute, I wanted nothing to do with the added stress, inconvenience and lost time. So when I was hired at my final career destination, we packed up everything and moved to the least undesirable (to us) of the available domiciles at the time. We have lived in the Phoenix area for almost 30 years since, where I have enjoyed the luxury and convenience of driving to work.

One of the nice things about the Phoenix area is that within about a 100-mile radius of Sky Harbor Airport (KPHX) are literally dozens of airpark communities.

An overview of the Mogollon Airpark in Arizona. It's greener and lusher than you'd expect from the Grand Canyon State.

Myron Nelson

Myron Nelson soloed at 16 and has been a professional pilot for over 30 years, having flown for Lake Powell Air, SkyWest Airlines, and Southwest Airlines. He also flies for the Flying Samaritans, a volunteer, not-for-profit organization that provides medical and dental care in Baja California, Mexico. A first-time builder, Myron currently flies N24EV, his beautiful RV-10. He has also owned a Cessna 150 and a Socata TB-9.

Photos: Larry Driver and Myron Nelson

Getting ahead of the discussion a bit, but here's a preview of the finished hangar and loft (left). There's a lot of work between concept and completion. Hard to argue with your purchase decision when this is the view out the loft window (right).

One, Hangar Haciendas (AZ90), is only about 8 miles from Sky Harbor. The greater Phoenix area includes one of the oldest and most iconic airparks in the country in SkyRanch at Carefree (18AZ), which has existed since the 1950s. Supposedly, newsman Hugh Downs built one of the first hangar residences there, and it has been a popular hangout over the decades for celebrities such as Dick Van Dyke, Bob Hope and Paul Harvey. The area also includes Stellar Airpark (P19) in Chandler, which is popular with airline pilots, plus one of the newest Airpark developments in the country, Pegasus Airpark (5AZ3), in Queen Creek.

A little further out from base zero is an interesting development called Mazatal Mountain in Payson, Arizona, about an hour and a half drive from Phoenix. This is a cooperative association between a public municipal airport (KPAN) and a private airpark development connected by a taxiway and an electric gate. An attractive "best of both worlds" scenario that I'm sure has been incorporated at other locations as it makes total sense in many ways.

My Approach

Since I am still working (last I checked), and we've spent more than 20 years in a home and neighborhood that we really enjoy—plus nine grandkids (last I checked) living fairly close by—our airpark quest focused more on a part-time vacation/climate change situation, since we planned to maintain a residence in the metro Phoenix area. My wife and I are both originally from tall-pine country and often miss that environment. That led us to a high-country development called the Mogollon Airpark (AZ82) in Overgaard, Arizona.

At only a two and a half hour drive or a (much preferred) half-hour flight in the RV, the airpark was close enough to my work to be convenient. Yet at over 6600 feet elevation, it offers a vastly different climate and environment than the Phoenix valley. Think pine trees and elk instead of cactus and scorpions. It's a great place to escape the oppressive heat in summer and to enjoy snow days in winter. We also had dear friends who already lived there, which is always a positive.

Just like it would take a fleet of aircraft to satisfy every pilot itch, an airpark choice is a compromise as well. Mogollon checked the most squares for us, so we started watching the real estate market carefully several years ago. Properties at Mogollon consist of two basic types: home/hangar units on one lot with taxiway access or hangar lots that have separate home lots that are set back a bit from the runway. Even though the development has been established for decades, it is quite large, so about 250 properties of both types are currently available for sale either as previously owned homes or raw land. The development appears to me to be about three-quarters built out. From a casual observation I would guess that about a third of the residents are full time. Most owners have a connection to Arizona. Some to an adjoining state. Some come from far across the country and a few even a totally different country.

As a pilot wanting to build another airplane, I was most interested in a home/hangar single lot with taxiway access. My dear wife, however, liked how the detached home lots were generally larger and more forested. So we compromised and went the way she preferred. Let's be honest here: For most pilots, getting a non-pilot significant other to even entertain living on an airpark is a huge win. After 39 years of wedded bliss, I figured it best to not press my luck. We found a nice combination of a quarter-acre hangar lot at one end of the runway attached (by assignment) to a heavily treed corner lot of over an acre, the two parcels separated by about 100 yards. We made an offer and were soon happy owners.

The author's view from inside the hangar. For now, it's full of a Van's RV-10. But what could be next?

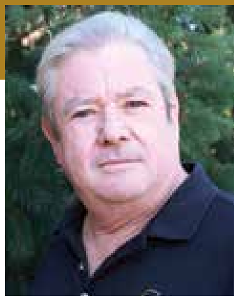
Okay, Let's Build

We were referred to a draftsman in the area who had drawn numerous plans for the development. As simple as hangars may seem, they can get quite complicated, especially with respect to their doors. Experience and familiarity are important for success. The same can be said for choosing contractors. I wish that I could say that dealing with an architectural committee of an airpark homeowners association (HOA) was pleasant, simple and hassle free. *I wish I could say that.* Moving on.

As I spoke with friends during this process, I heard concerns that general aviation was graying out. Wouldn't airparks be graying out as well? I can see that point and definitely considered that situation. One countering argument: Retiring airline pilots like myself make for a rather large demographic of potential airpark buyers and at no time in history have so many airline pilots been retiring as there will be over the next several years. That statistic bodes well for the airpark market.

One consideration at our airpark, and I am sure others, is that the residences themselves are attractive enough to entice non-aviators to buy in and use the hangars as convenient garages for boats, RVs (the other kind), snowmobiles and the like. This can be a blessing and a curse. While this desirability makes for a more active real estate market, always nice for sellers, it can create problems when the time comes to address aviation-related costs and/or noise complaints. While I am not aware of any in particular, I am sure that an airpark runway somewhere has been dug up and repurposed—as have numerous other general aviation airstrips over the years. For example, the airport I soloed off of as a teen in 1975, Strawberry Glenn in Boise, Idaho, is covered in houses today, lamentably without a trace of its former aero-glory.

For an incurable airplane nut, there is a very special feeling taxiing up to your hangar/home and opening the hangar door from a remote in the cockpit. A dream come true for me. Earlier in this column, I hinted at the challenges of having our house and hangar built; next month, I'll offer more detail on that. ✈



AERO 'LECTRICS

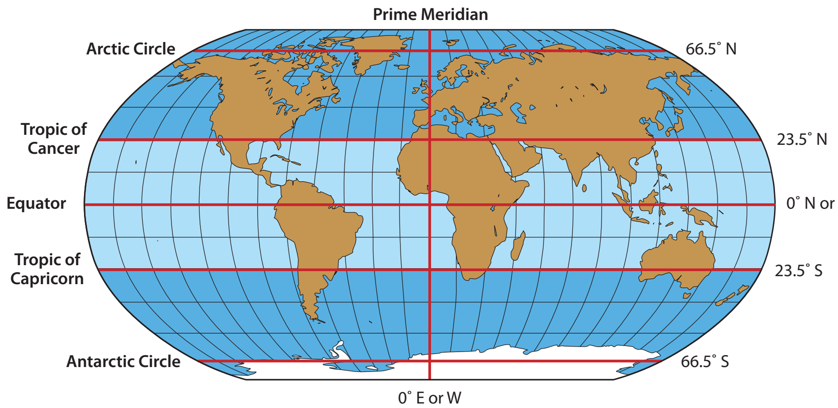
The Solar HOG

So, we've got this huge furnace about 94 million miles away from us, and we want to tap into that furnace's power. Since this furnace is "burning" about one trillion one-megaton hydrogen bombs per second (about 500 trillion trillion [5 x 10^{26}] watts per second), it seems reasonable that even at 94 million miles away, we ought to be able to get a little tiny bit of that power to light our hangar and run a few small tools.

So how much power per square foot does that equate to on the surface of Earth? Roughly 60 watts of infrared, 50 watts of visible, and 4 watts of ultraviolet. But the lower end of the spectrum (infrared) doesn't have enough energy to knock those electrons around to produce power, and the higher end of the spectrum does a Babe Ruth and knocks the electrons so far out of the ballpark they don't produce power either. It is the visible (and tilted towards the high, or blue-violet, end) that produces the power.

A few more problems to consider: The earth does *not* have a circular orbit around the sun—it is elliptical. Also, the earth is tilted so that it is about 24° relative to its orbit. It is closer to the sun in the (northern hemisphere) winter and farther away in the summer. Our colleagues south of the equator can get a fair amount more solar power than we can in the summer, but then again, their summers are significantly hotter than ours are, and they get less power in the winter.

The sun traces out a sine wave between the Tropic of Cancer (a line of latitude 23.5° north of the equator just ticking the Florida Keys) and the Tropic of Capricorn (a similar line south of the Equator slicing Australia in almost perfect half. It just touches Cancer on June 21 and swings south to Capricorn on December 21, thus defining the first day of winter and the first day of summer, also called by scientists the winter and summer solstice. (Solstice means "the sun stands still," which it does for that one day directly over Cancer and Capricorn.)



The sun traces out a sine wave between the Tropic of Cancer and the Tropic of Capricorn. It just touches Cancer on June 21 and swings south to Capricorn on December 21, thus defining the first day of winter and the first day of summer.

OK, enough of the theory; let's get to the point: Unless you sit on your roof with a micrometer and a very seriously gimbaled solar cell mechanism all day, every day, you will never get perfect insolation.

Insolation is the measure of how much power falls per square foot and how much of the possible power does the solar cell actually produce. For example, in the winter everybody has to pitch their solar cells up from 0° (flat on the roof) to some rather large number to point them at the winter sun low on the southern horizon. If you kept that pitch angle constant, you would lose a lot of the direct summer sun when the sun is much higher in the sky during the day.

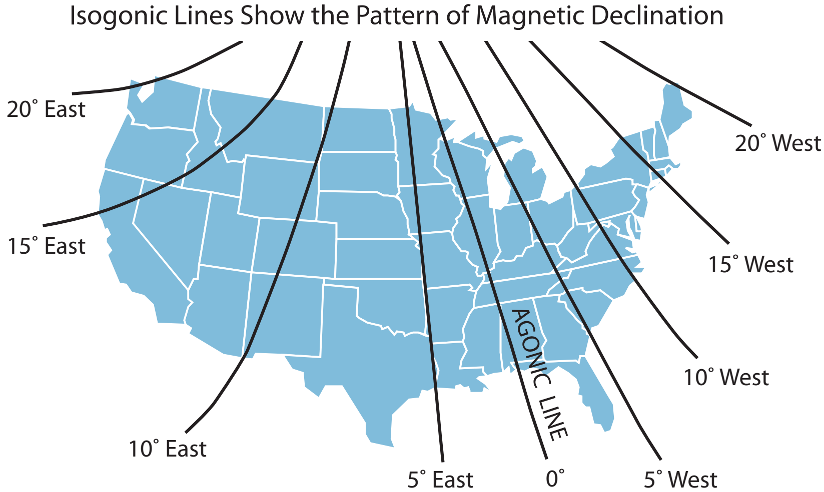
The purist would say that to get absolutely every bit of energy that Old Sol is sending us, you would have to continuously keep readjusting the pitch angle *and* the pointing angle all day, every day, forever. Isn't going to happen. With reasonable compromises, we can get about 75% of that power all day, every day.

I'm going to present three choices for pitch angle (next column) and one choice for pointing angle, and I'm going to discuss pointing angle first.

As we all know, the sun rises in the east and sets in the west. One of my Wisconsin buddies told me that this is the waffle rule: "Da waffle rises in der yeast, and sets behind der vest." Be that as it may, we need to point our solar cell directly to the south to get the maximum insolation. Remember, the sun has *absolutely* no idea where the earth's magnetic pole is. It shines directly on the *true* north and

Jim Weir

Jim is the chief avioniker at RST Engineering. He answers avionics questions in the Maintenance Bay section of www.pilotsofamerica.com. *His technical advisor, Cyndi Weir, got her master's degree in English and journalism and keeps Jim on the straight and narrow. Check out their website at* www.rstengineering.com/kitplanes *for previous articles and supplements.*



In the western United States, a magnetic compass will point *east* of the true north pole. In the eastern states, it will point *west* of the true north pole.

true south poles. How can we tell where true north and south are? We'll use some simple math and a few tricks.

When I was first learning to fly (using pterodactyls with saddles), magnetic north was in Greenland. It has since migrated to eastern Canada since that liquid iron ball in the center of the earth keeps moving around. There is a line that you need to know about…the *agonic* line. This is the straight line that goes from the Santa Claus north pole, through Greenland's magnetic north pole, through the Wisconsin Dells, through St. Louis, through Nashville and through Alabama's Maxwell Air Force Base. This line lines up the *magnetic* north pole with the *true* north pole. No correction necessary.

For those of us east or west of the agonic line, there are corrections necessary to use a compass to find true north. It ranges from as much as 20° east declination in Seattle to as much as 20° west declination north of Presque Isle, Maine.

The conversion from magnetic to true has a lot of ways to make these math problems rememberable: East is least and west is best. True virgins make dull company. And a few more that can't be printed in a family magazine. And most of which we forget completely once we pass the FAA written.

It's better to think about this logically. Here in California, at about 13° east compass declination, when I face north I picture Greenland to the right of the north pole. Therefore, my compass will point 13° to the east of the actual true north pole. I must therefore subtract 13° from my compass reading to convert compass direction to true direction. Bottom line? 360 – 13 = 347 so when I point my compass to 347°, I am pointed toward the true north pole. Subtracting 180° says that when my compass is pointed due south at 167°, it is pointed at the true south pole.

Three Rules to Remember

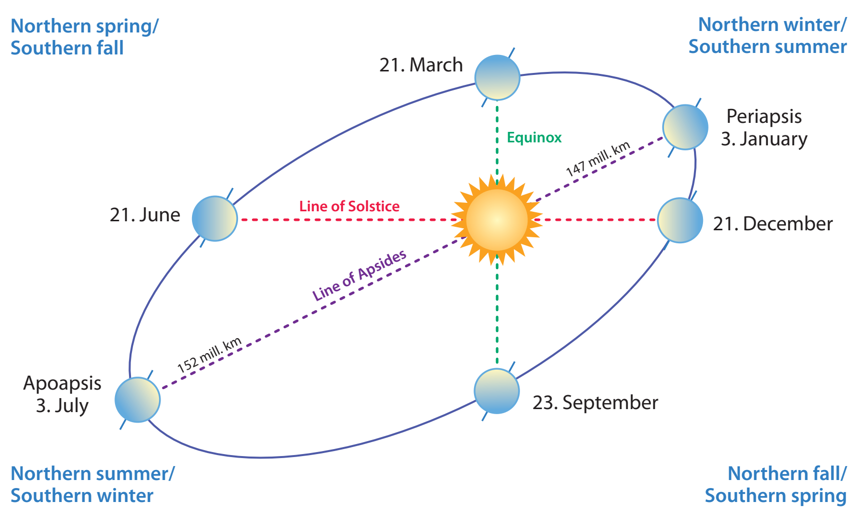
1. 360° *minus* east declination = compass reading to point true north.
2. 360° *plus* west declination = compass reading to point true north.
3. True north compass reading *minus* or *plus* 180° is the compass reading for true south (whichever gives you something close to south).

So, where do we get correct information for our airports? Unfortunately, the FAA database is *way* behind in these updates but *www.gcmap.com/airport* has all the data for every airport in the world. For example, my local airport, Nevada County Intentional Airpatch (KGOO), can be found at *www.gcmap.com/airport/KGOO*. (Don't forget the K in front of the three-letter ID). Here's the basic information:

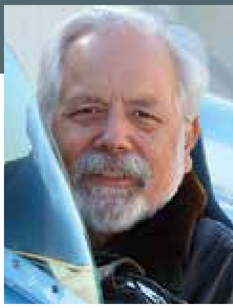
Nevada County Airport	
Type:	Airport (Airfield)
Use:	Public/Civil
Latitude:	39°13'27"N (39.224056)
Longitude:	121°00'09"W (-121.002555)
Datum:	WGS 1984
Elevation:	3157 ft (962 m)
Variation:	**13.44°E (WMM2020 magnetic declination)**

Note that it also includes latitude 39° that we are going to have to use in the next HOG column. I'm going to give the HOG a rest for a month and answer a question I've been asked at least a dozen times in the past few years…how to get your iPad music into your aircraft audio system.

This is fun for me…Until then…Stay tuned…



The various seasons in the northern and southern hemisphere as the earth travels around the sun.



Going Around

Gallons of ink have been dedicated—with only minor effect—to figuring out what it is that joins pilots together. But clearly there's something in the air because pilots of every distinction display an inherent magnetism to their own kind, an ability to ferret one another out from the otherwise sameness of the greater social stream. Furthermore, in a rare case of interspecies mingling, once identified, we pilots apparently communicate natively regardless of the hour and rating disparity among the communicants.

And it was so just a few weeks back when I found myself chewing the tail off the windsock in a neighbor's hangar. Unlike myself, this fellow is a professional pilot, a helicopter jockey for Uncle Sam. His job description includes turbines, FLIRs and gimbal-mounted rotary cannons on tandem-seat helicopters, so old biplane pilots can only listen and learn on that account. On the other hand he also owns a Lancair 360, so there's something a little more in common there.

As it typically does, the subject eventually turned to landings. And I was a bit surprised when discussing a recent Lancair approach gone a bit off the rails that this pro said, "I'm not afraid to admit to going around." Well, yeah, of course. Everybody goes around, right?

As a reform-minded egotist I often delude myself into thinking I too am sufficiently saintly to admit one of my *faux pas*, especially if no one was watching. But I get it. After all that training and practice, pro pilots flying near daily probably see an unforced go-around as an abject failure on their part, but not me. Good Lord, what can be more different than landing a 7-ton helicopter all week, then greasing a wingless wonder such as the Lancair onto a 2180-foot runway on Sunday? Talk about different worlds…the occasional go-around is to be expected and, more to my thinking, such maneuvers are a welcome display of intelligence and experience at work. It sure beats trucking your pride and joy out of a bean field for a year of repairs.

On top of being smart, a well-executed go-around is not the simplest piloting. For one thing many of us don't do them that often, so it's all too easy to forget parts of the procedure or what order to do them in. It's asking a bit much of any human to correctly recall a multistep process under duress when they haven't practiced or likely even tried to recall the steps in years.

If not performing all of the procedure or incorrect order is part of the problem,

Seen from the ground a timely go-around looks much like a high pass or normal takeoff as Jon Levi demonstrates here in his patriotic S-18 Thorp. Go-arounds preceded by a tromboning throttle and mild aerobatics are probably a little late but useful nonetheless.

Tom Wilson

Pumping avgas and waxing flight school airplanes got Tom into general aviation in 1973, but the lure of racing cars and motorcycles sent him down a motor journalism career heavy on engines and racing. Today he still writes for peanuts and flies for fun.

so is rushing through those parts we do remember. I tend to hammer the throttle forward when I finally admit my choices are either trees or running off the end of the runway into that bean field. So motivated, it's a surprise I don't break the throttle lever off while the 'ol six banger takes in a big gulp of air followed by a gasp as the fuel system tries to keep up. A slightly less energetic throttle application would apply more thrust sooner, or at least would be easier on the engine. And as the whole point is to be able to reuse the engine, along with the remainder of the airplane plus one's body, a bit of finesse is a good thing.

A major reason I'm so eager with the throttle is it seems the go-arounds I make are last-second affairs. If someone pulls out onto the runway while you're on final, there's typically not a lot of critical timing involved. You can immediately comprehend the situation, take a reflective second to figure out where to aim your airplane in anticipation of the inevitable sharing of airspace with the guy taking off, and then fiddle with knobs, levers and the stick as you go from gliding to climbing. Even if you forget and leave the carb heat applied or the flaps hanging out 20°, there's time to rectify those oversights when you double-check your situation immediately after your initial response. But that's not my typical go-around.

More likely I find myself blasting away with the loud lever while attempting to salvage a landing gone high and right. This leads to dribbling down the runway like a runaway basketball while the crosswind scoops everything into Tilt-A-Whirl mode. About when I find the flight controls boxed in opposite corners as I chase wobbly wings and a porpoising nose, the concept that if I just gave it full throttle, let it straighten itself out and take it around for another try rises to prominence. By then time is more critical. It's best to have the go-around response pretty automatic under these conditions as pushing when you should be pulling, or trying to climb with partial power (carb heat) or high drag (flaps) is less forgiving when you're starting pretty much from the ground to begin with.

Let's also observe my near habitual operation off a shorter runway has reinforced the go-around as a smart option and might be one reason I'll take that option sooner than other flyboys. To continue with our botch-and-bounce scenario, it may not be textbook, but who reading this hasn't collected an errant airplane with a shot of power and stabilized controls, then carefully took the power off and settled into a nice touchdown? It works if you're flying the majority of modest-performance airplanes on a 5000-foot runway and initially fouled things up reasonably close to the approach end. But it's not the go-to response at shorter strips.

Another factor is control layout. If you always fly the same airplane then the cockpit could have been laid out by The Three Stooges and it shouldn't matter much as you'll be native on where to reach for the flap switch and such. But if you move among airplanes, it's amazing what creatures of habit we are and where you'll reach in near panic. Find yourself staring at the gas truck rapidly filling your windshield, and you'll end up going for the throttle in the airplane you trained in decades ago rather than the one you built last year and are flying that instant.

Furthermore, if you do subscribe to a panel layout from Larry, Curly and Moe, designers extraordinaire, then sell the airplane, what about the next guy? I've got one of those planes. The throttle is on the left cockpit side. The prop vernier is in the left corner of the panel, the mixture on a center console by my left calf, the elevator trim by my right calf, the turbo control (used to be) under the pilot's seat(!), the tachometer is in the right armrest under my elbow, and thank God the airplane doesn't have flaps, either wing or cowl. After around 600 hours it's pretty familiar, but I'm lost in the typical RV.

And so, for my two cents, given the type of flying we do and the airplanes we do it in, well-executed go-arounds are a thing of beauty. They may be children of necessity, born of human imprecision, but I sure don't mind admitting to doing them as often as necessary. And if building a new bird, I'd stick to a more or less conventional cockpit layout if possible.

Leaky Static Lines

Ever wonder why static systems often start to leak after a couple of years? See the little plastic insert between the two tubes in the photo? It is supposed to be inserted into the end of the tube. Without it, the tubing will eventually start to collapse as seen on the right tube and cause a leak!

—Vic Syracuse

Photo: Tom Wilson

ARCHIVE

October 1994

Our October 1994 issue led off with the "wet and wonderful" Seawind 3000 composite amphibian and a thorough flight test of Nat Puffer's Cozy, all of which seem right in line with our coverage of the Long-EZ this month in our recurring Buying Used series.

The ever-young LeRoy Cook flew the Seawind in Florida for his report, saying that after a change in ownership and "the new guidance of SNA, Inc., kits are available and being shipped. At long last, a half-dozen Seawinds should be up and flying before the year's end." During the flight test, LeRoy said that "wide open, the Seawind 3000 is a 200-mph airplane, and with 75% power it trues out at 191 mph at 8000 feet." That's with the six-cylinder, 300-hp Lycoming IO-540 in the big pod cantilevered from the vertical stabilizer. The Seawind was offered as a kit through 2002, when the company stopped that effort to focus on certifying the design. Roughly 80 kits were completed. In '94, the kit price was $41,900, though a Kwick Kit was a $9800 option.

Also in this issue is a fascinating feature on Cozy designer Nat Puffer's efforts to test for deep-stall characteristics in a canard design. It began when test pilot Jim Patton found himself in a main-wing stall with a rotational component during tests of the Cozy with a far-aft loading. One of Puffer's solutions? A 135-pound movable weight inside the cockpit to allow real-time changes in CG so they could "inch up" on the adverse flight characteristics in a single flight. Eventually, Puffer's testing proved that two relatively simple changes—shortening the canard span by a total of 6 inches and adding small winglets below the vertical tip sails—allowed him to get acceptable behavior at the aft CG limit and still have good pitch control at the forward limit.

Our Avionics Special section revealed the boom in GPS navigators, featuring the new Magellan Skyblazer, Garmin's 95 XL and the II Morrow Apollo 920, among others. We also featured the new II Morrow Apollo NMS 2001 and Garmin GPS 1550 TSO panel mounts. Bendix/King's KLN 90B, Arnav's FMS 5000 and Northstar's M3 rounded out the choices. Don't forget that Bendix/King had recently refaced its popular radios with a gray plastic visage and referred to them as the Crown series, aimed at the low-cost and homebuilt side of the market.

So much fun in '94. Nat Puffer took flight testing of his Cozy seriously; the KIS was very much a thing; and Bendix/King would send you an actual-size, peel-and-stick photo set to see if the new Crown line fit your panel.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