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On the cover: John McBean, president of Kitfox Aircraft, enjoys a flight in an S7 Super Sport on a near-perfect Idaho day. Photographed by Richard VanderMeulen.

EDITOR'S LOG

Experimental Vs. Certified

As I go through our back issues for our *Archive* page and relive the world of homebuilding in the 1980s (and, by extension, even before that), it strikes me how far we've come. Once considered true outliers, somewhat crazy craftsmen/renegades building flimsy contraptions in their basements from nothing more than discarded two-by-fours and swing set parts—not true, of course—homebuilders are now tantalizingly mainstream. On any airport of a certain size, there will be an airplane being begun or readied for first flight—and anywhere in between. On mine, there are many.

In those early days, homebuilders took what they could get. Used engines, often from wrecked Cessna 150s or Cherokees, rebuilt for our needs. Avionics found at the local fly market ready for a second lease on life after the Bonanza owner upgraded. In those days, there was no dedicated product or heavily strategized marketing plan for Experimentals. We roamed the boneyards and airshows looking for deals, also spinning by the local airport bulletin board hopeful to find a 3x5 card thumbtacked there on the cork, promising some dream component.

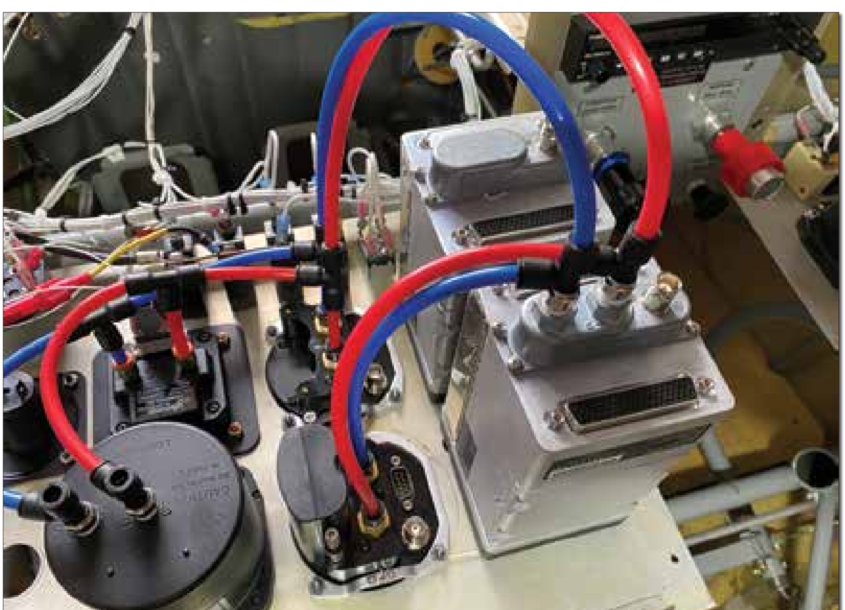
Now, However

It's a whole different thing today. I was lucky enough to watch this emerge through the 1990s: a strong, Experimental-first product set that fully leveraged the freedoms we have as designers and builders. This is how we got custom engines from the big manufacturers. This is how companies like TruTrak Flight Systems, now part of Honeywell and BendixKing, got started. This is why, for years, pilots of certified aircraft peered through the canopies of parked RVs and Lancairs and pined for the advanced, lightweight, low-cost avionics they saw. We all sort of know this without thinking too hard about it.

The reason I bring it up here? Over the last few weeks, I've been in the process of testing new products in my GlaStar. (Once begun, this process never stops. Paul Dye warned me, and yet I failed to heed!)

Part of this latest round has involved fitting Garmin's new GI 275 round instruments. I'll give you a full review once I've finished this work and have enough flying time to form a full opinion, but let's say the installation process—equal parts wire cutting and book learning, it should be said—has been more than a little interesting. What's more, this endeavor has answered my initial question about why the new Garmin boxes are expensive relative to the existing product for Experimentals.

This answer came as the differences were laid bare in one image. In the process of wiring and plumbing the panel, I had two GI 275s mounted next to a pair of G5s and saw, from the back, just how radically different these instruments are in terms of approach. The G5 is light, compact, mostly plastic. It's inexpensive for what it does and has been, in my experience, thoroughly reliable. It's not very deep and can be readied for use with little more than connections to power, ground and the pitot-static system. Even the GPS antenna is built in. The G5 reflects



The two GI 275s on the far right compared to the pair of G5s in the middle. One look says a lot about the intentions for each product.

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 central Oregon. Marc has 4500 hours spread over 200-plus types and three decades of flying.

Garmin's apparent belief that it could go in any aircraft, from simple lightweights to high-end stuff as a backup to larger glass. I hasten to call the G5 toy-like, but it was clearly designed with cost, complexity and low weight in mind.

Now look at the GI 275. It's a tank. With a die-cast aluminum case, hearty bezel and thick knobs with we-mean-business detents, the 275 feels ready to go into a King Air, which, well, it is. The battery module—optional for the non-essential flight displays but required for the primary attitude version—snaps into a slot with a satisfying thunk, is bolstered by rubber stoppers and fits under a tight-fitting, metal cover. I once had a Beech Bonanza with older Collins radios and looking over the GI 275 reminded me of how overbuilt certified avionics can be. At 3 pounds, the GI 275 with internal ADAHRS is three times the weight of a G5. It's also longer, though not as deep as the cranky old vacuum DG that I'm finally kicking to the curb.

More telling than the length of the install manual, nearly 500 pages, are the ways the GI 275 talks to the rest of the airplane. In the G5, reflecting the much more open architecture found in homebuilts, a CAN bus system (two wires) communicates with external modules, including outside-air temp, a remote magnetometer, an ARINC 429 convertor (necessary with an IFR GPS), a remote autopilot control panel and the servos themselves. The understanding is that modern Experimentals aren't going to have much if any legacy equipment. (I suppose there could be a homebuilt running around with a repurposed Cessna 300-series autopilot, but I haven't seen it.)

Part of the 275's complexity is that Garmin has accommodated all manner of existing infrastructure, including newer and ancient autopilots, various navigators and other pieces of vintage equipment likely to be in an older certified airplane. The 275's architecture also eschews most remote modules—the OAT probe connects directly into the unit, for example, and each 275 model has both ARINC 429 ports and Ethernet (also called HSDB, or high-speed data bus). In practice, one GI 275 can connect directly to a modern navigator with just four wires to share nav and EFIS/air-data back and forth, seamlessly. It can take that info and output analog signals to autopilots and accept analog signals from older navigators. It is, from both design and execution standpoints, an amazing device.

And So?

Imagine that the Experimental sub-market for cool, innovative products never materialized. Then imagine ogling an instrument like the 275 and wondering how it might fit into our machines. Imagine teaching yourself how to manage a pair of 78-pin high-density connectors when your day job isn't as an avionics installer. Imagine your dismay upon discovering that you're using only a fraction of the instrument's capabilities, but paying for them all. You don't have to, and that's my point. Sometimes you have to look back to appreciate how good we have it. The profusion of Experimental-only (or Experimental-first) products is, when you think about it, fairly out of proportion to the number of aircraft out there. (See Ron Wanttaja's piece on Page 44 for more on homebuilt registration numbers.) We are all the beneficiaries of relatively low-cost, high-capability pieces for our aircraft—engines, accessories, avionics, all of it. As much as I love to renew my understanding of homebuilt innovation in its early days, I'm in absolutely no rush to go back. ✈

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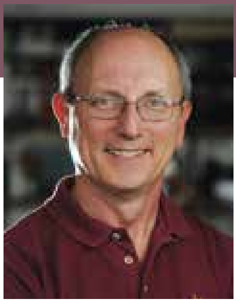
Photo: Marc Cook



In-Flight Weather: Practice for Survival

This was going to get ugly.

Crossing southern Louisiana in the middle of the afternoon in late May is never pretty. Today was going to be no exception. Thunderstorms were popping up everywhere, and a long occluded front about 100 miles north of the coast stretching from Texas to Florida was holding the elements of convection right in the cooking pot, feeding the boiling cloud masses and generating some small but strong storm cells. They were everywhere, and there was no way around.

Headed west, as low as we dared to go, it was clear that we didn't have much choice but to press on. The cells had us surrounded and the line ahead was narrow but strong. The NEXRAD radar was showing about 3 miles of red surrounding a mile of a darker shade I had never seen before, and the gradient from green to yellow and into the nasty colors was extremely tight.

I had Louise close in trail and we pressed on through. As we hit the line, the visibility dropped to near zero and the water was cascading so hard off the windshield that we might as well have been in a submarine.

Oh, wait a minute—you didn't think I'd be stupid enough to be doing this in an airplane, did you? No, no, no…this was a surface job.

It was about 10 years ago and XM satellite weather had just become a thing. I was "commanding" a 26-foot diesel rental truck and Louise was chasing in her Toyota 4Runner with Karst the malamute as copilot. We were moving her household things from Washington to Houston, and I had never really played with the Garmin GPSMAP 396 and XM on a road trip before.

This was an interesting opportunity to use it to actually penetrate some weather—safely, with wheels on the ground and the ability to slowly coast down to whatever speed was necessary to stay safe—and see how the depictions on the screen correlate to the actual weather. If you are flying with NEXRAD (either XM or ADS-B) a lot, especially in the Thunder Belt, you might do the same thing—take it along on the road and see from the ground what you *never* want to see in the air! Today, you can take your favorite app

When the sky looks like this, it is far better to be on the ground wishing you were in the air rather than the other way around!

Paul Dye

Paul Dye, KITPLANES® Editor at Large, retired as a Lead Flight Director for NASA's Human Space Flight program, with 40 years of aerospace experience on everything from Cubs to the Space Shuttle. An avid homebuilder, he began flying and working on airplanes as a teen, and has experience with a wide range of construction techniques and materials. He flies an RV-8 and Subsonex jet that he built, an RV-3 that he built with his pilot wife, as well as a Dream Tundra they completed. Currently, they are building a Xenos motorglider. A commercially licensed pilot, he has logged over 5000 hours in many different types of aircraft and is an A&P, EAA Tech Counselor and Flight Advisor, as well as a member of the Homebuilder's Council. He consults and collaborates in aerospace operations and flight-testing projects across the country.

along but be aware that some weather depictions are different when using an internet source than you will see from an in-flight ADS-B feed.

Learning the Limitations

Recently, the FAA has published notes on the limitations of using datalink weather in the cockpit, and it is worth reiterating that there are indeed real-world limitations. While I am convinced that having graphical weather information in the cockpit is the greatest single advancement in cross-country aviation safety since the invention of the wing, I go out of my way to also make sure that people know that, just like any tool, you have to use it with some smarts—and know when you can't rely on it.

Whether your in-cockpit weather is delivered via satellite or through an ADS-B connection, the data you receive is going to be delayed from real time. I like to point out that while NEXRAD weather radar is great, the rest of the data available is just as valuable—but you have to understand its limitations.

For example, I like to use the downlinked METAR data when flying first thing in the morning. Airport observations frequently show low ceilings and poor visibilities between sunrise and mid-morning because of narrow temperature/dewpoint spreads—this is just the "nature of nature." So watching the weather improve as the morning goes along is reassuring when I am covering long distances. But you have to remember that METARs are generally issued once an hour and much can change in 60 minutes. Dialing in nearby AWOS stations is a better way to get a handle on fast-changing trends—at least those within radio range. The METAR data, therefore, needs to be looked at along with the clock—and the best time to check it is just after the top of the hour when all the latest reports have just come in and have made it to your device.

Winds aloft data is another good example of "make sure you know what you are looking at." The info that we get through the data links is *forecast* wind data, not what is actually going on. Winds aloft forecasts are probably

Early in-cockpit weather options like this Garmin GPSMAP 496, successor to the 396, relied on XM Weather data and could present a fairly accurate representation of weather. But what you had on the screen wasn't always what you'd see out the windscreen.

some of the greatest works of fiction in the entire weather universe, no matter how you get them (preflight or in flight), and while they will give you a reasonable idea what might be happening if you were to change altitudes, it is rare that you get the whole story without actually going up and snooping around. The advent of real-time wind data in the cockpit (available on most modern EFISes) can help much more than the forecasts that we all grew up with—and what we read off the screen tells us how reliable the forecasts really are.

But let's get back to NEXRAD and that trip along Interstate 10. Thunderstorms are the very definition of dynamic weather events. They grow and change rapidly—and the faster they change, the more violent they tend to be. When faced with a wide area of precipitation or building precipitation in our path, it is important to look first to the age of the data on our receiver (usually indicated in minutes since the last image was received), and second to have a look out the window to see if what the screen tells us makes sense with what is actually out there. The minutes shown on the display indicate the time since the data was received—not from when it was generated, and numerous technical issues can cause delays of several minutes. My rule is that if I don't see a significant change in the picture with each update, then perhaps the weather is outpacing the delivery of the data—a big red warning flag that tells me that it might be time to choose another plan.

Because I tend to rely on out-the-window cues to help confirm what I am seeing on datalink weather, I am not inclined to be in the clouds with dynamic weather (such as thunderstorms) shown on the radar. Once you find yourself in the clouds, the ability to judge the validity of what comes over the link is diminished considerably. Most light airplanes—no, *all* light airplanes—are going to come out on the short end of an encounter with any thunderstorm worth the name, and that's a risk not worth taking. Therefore, I stay out of the clouds when convective activity is present, except for unique circumstances, such as with widely spaced cells with little dynamic activity or change observed over a long period of time.

This is why a trip with a portable NEXRAD on the ground can be so valuable—you get to look at the weather on the screen, then actually penetrate it and see what it's like. And then ask yourself if you'd like to be inside that same weather up in the air! This is probably the best lesson you can get on how well the system actually works.

Weather Strategery

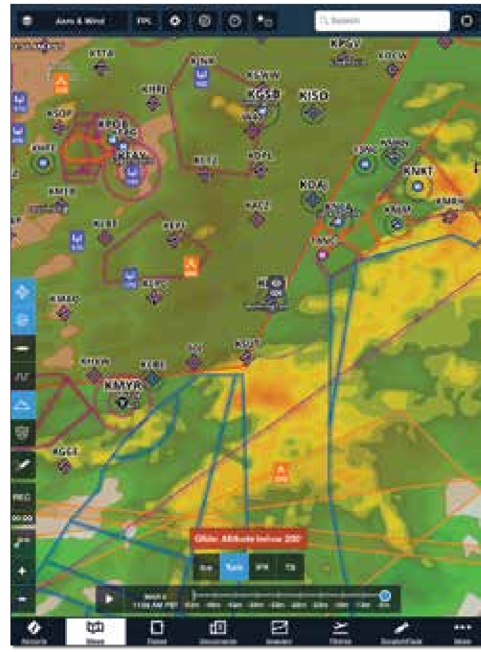
So you've "penetrated" the weather safely on the ground and learned that you probably don't want to find yourself in anything more than a yellow return. How do you apply this to your

Photos: Marc Cook and Shutterstock

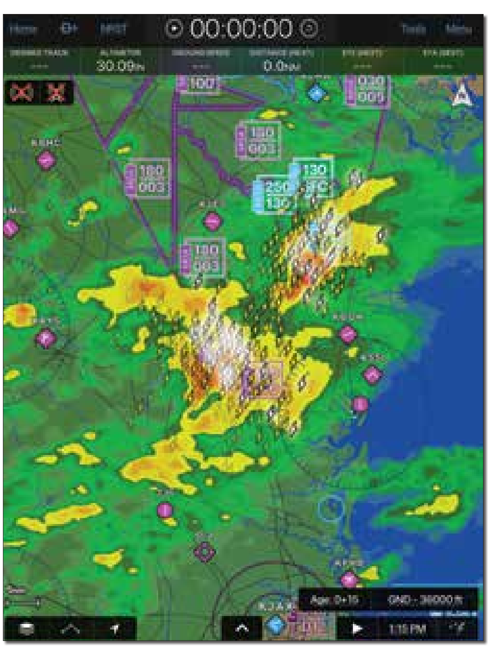
everyday flying? Well, obviously, make sure that you stay out of the orange and red, right? It might seem obvious, but several pilots every year still manage to come out of the bottom of thunderstorms without wings.

So let's talk strategy. The biggest thing that XM gives you over actual airborne weather radar is "the big picture." With airborne radar, you get to see what is directly ahead of you—and only as far as the power of the radar set can penetrate. With NEXRAD data, you can see not only what is ahead, to the sides and behind you—you can also see what is *beyond* what is ahead of you. Being able to see to the sides and behind is a great way to make sure that you are never cut off from a safe line of retreat. Seeing *beyond* what is directly ahead is a good way to tell if going on is even worth it. If you are facing a small area of cells and/or precipitation ahead of you, but have clear spaces between and nothing beyond, then you are probably going to be able to get through and continue on your way. If, however, you are looking at a wide area of weather ahead, something that extends for 50–100 miles, you are probably going to get yourself in trouble if you press on. Large area masses of convection generally get worse before they get better and, once inside, you are unlikely to find a safe way out.

When faced with weather ahead, I operate with a "safe retreat" rule. I always want a straight course to an airport that is clear of anything more serious than green returns. I don't mind snooping up ahead a bit as long as I can turn around or deviate to the side, where I can get on the ground to sit things out. While this might seem a little limiting, the fact is that if I can't find a precipitation-free route around or through an area of convection, then I probably don't want to be in there with a light airplane—it can just get too bad too quickly. One useful tool in the NEXRAD data is when you start seeing actual "cells" being depicted. Red radar returns are bad enough, but the little cell depictions are the weather service's way of saying, "Hey dummy, you really don't want to go here!" Likewise, lightning data is another "keep out" sign that I always try to observe, especially because I am depending on the electrical equipment in the airplane to keep operating and feed me the information I need to stay out of trouble.



Modern weather, like this internet-derived depiction on ForeFlight, provide a lot of long-range information and "the big picture" but watch for data latency.



Lightning overlays can help confirm what you already suspect of convective weather, as seen through this internet-based data on the Garmin Pilot app. Really watch out when the rain starts to be depicted with organized cells.

Gulf Lessons

So what did we learn on that day on the gulf coast? Well, by direct observation we learned that when the rain gets into the red zone, it is the kind of stuff where the road is flooded! The kind of rain where it is so heavy that wipers are useless at 30 mph. I am guessing that at 160 knots, it might put so much water into the intake of a "snout cowl" RV that the engine just can't get enough air…

We learned that tight gradients are *really bad*! Green is the kind of rain that rinses the airplane but doesn't get it clean. Yellow is something you want to stay away from, but the occasional foray probably won't scare you too badly—so long as there isn't any red next to it. If there is red in the cell, I am not even going to get into the green—there is too much electrical charge in the convection. I have seen lightning bolts in the clear blue sky surrounding a tight storm—no thanks! The narrower the bands leading into the red, the faster the storm is developing, the more severe it will be. Finally, once you start seeing the XM identifying actual "cells" rather than areas of rain, it is time to go for an alternate plan, stay well away in the clear air and watch from afar.

I have always enjoyed watching thunderstorms, but I like doing it from a fairly safe place. It's a pain to drive in that weather (in this case, we were motoring on the Atchafalaya Bridge, 18 miles with no way off, or we probably would have pulled over), but completely unsafe to fly in. It is unfathomable to me what goes on in the minds of pilots who think they can fly through red radar returns—storms don't last that long, they will go away, and you can get through later. If you don't believe me, take your XM or internet-fed app like Garmin's Pilot or ForeFlight on a road trip and go "penetrate" some storms. You'll be a believer and, more importantly, a survivor. ✈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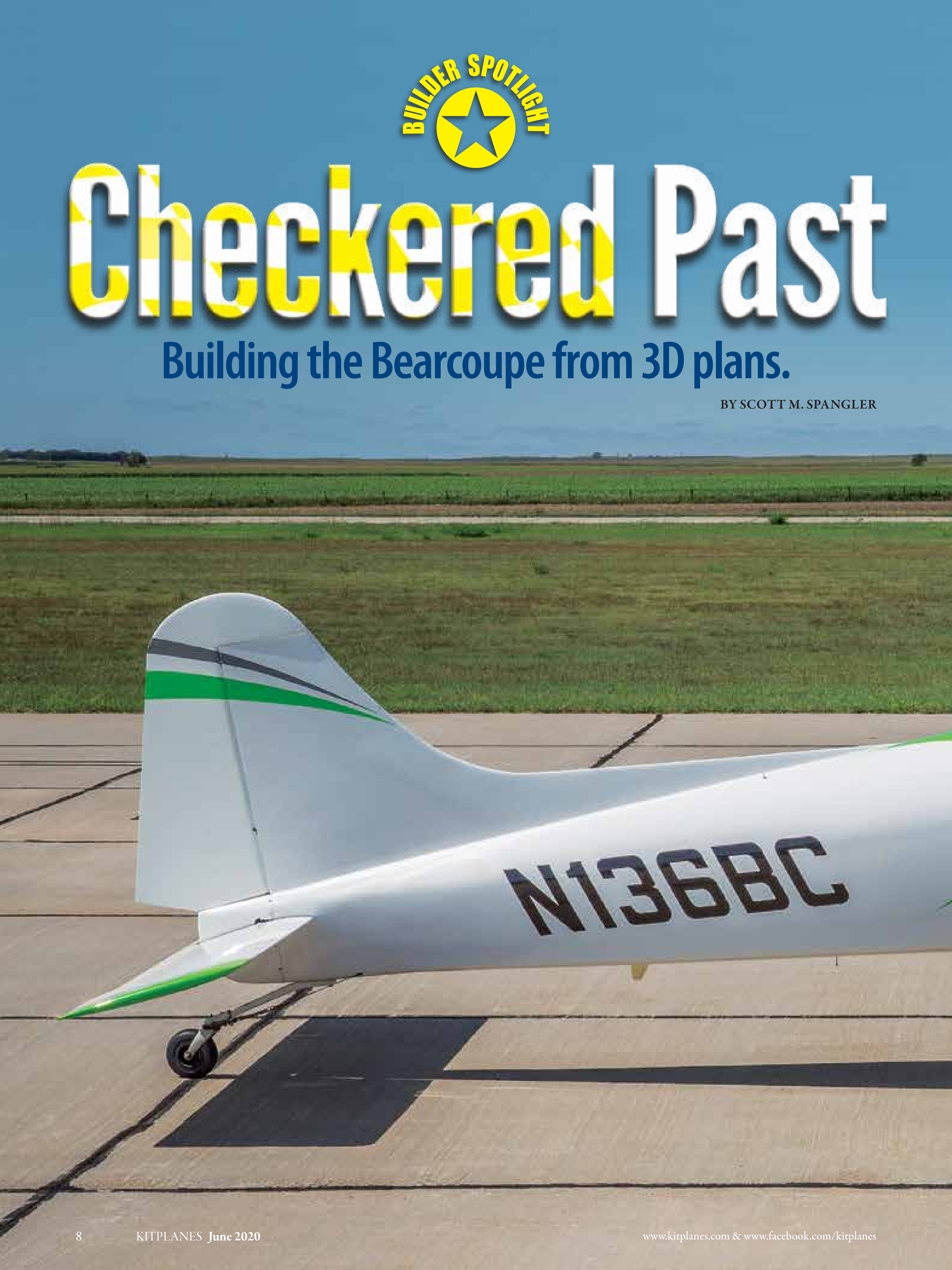


Checkered Past

Building the Bearcoupe from 3D plans.

BY SCOTT M. SPANGLER

Concretely explaining why a specific airplane appeals to a pilot is almost as easy as explaining why they fly. All Bob Bounds really knew when he first saw Fred Keller's Prospector STOL, named Plansbuilt Grand Champion at EAA Oshkosh 1989, is that he wanted one. "I asked him if there were plans, and Keller's answer was a strong and unequivocal '*No!*'," said Bounds.

Bounds lives in Grant, Nebraska, a small town of 1200 people 20 miles south of the Ogallala exit on Interstate 80 and 18 miles east of the Colorado border. It is the seat of Perkins County, and he is its now-retired postmaster. "I now work in an auto parts store because my wife, Deb, says I have to; if I'm not working, I start building stuff."

Stuff like a Rutan Quickie and VariEze. From the Grant Municipal Airport (GGF), Bounds flew the VariEze almost everywhere, including Keller's home state, Alaska. "A cross-country airplane with teeny tires, there are not a lot of places you can fly a VariEze, so I wanted a different airplane," and the Prospector remained at the top of his list.

When a flying friend said he'd ridden in a Prospector, Bounds asked if he knew Keller. "No, it was a guy named Tom Couples. Maybe he'd have plans for it, so I called him up." Couples and Keller were friends, so Keller built a Prospector for him. There were no plans, and that wasn't the only bad news. Couples' Prospector was a wreck; it choked on carb ice and went into the trees in Idaho.

With Bounds' building experience, he said Couples told him, "You should be able to build one with what's here." Bounds had never heard of a homebuilder who'd used wreckage as 3D plans,

Photos: Bob Bounds and Scott Spangler

so he wasn't so sure about that. "Still, it wouldn't hurt to look at it, so I loaded up my son and we drove to Kalispell, Montana," Bounds said.

"I ended up buying it from him, thinking maybe I can do this." Buying the remains in 2006 led, in part, to the airplane's moniker, *Checkered Past,* said Bounds. "It was borne of a wreck and rebuilt from one."

When they returned home with the trailer piled high with shrink-wrapped wreckage, Bounds said, "My wife was not very happy with me. 'You were just going to look!' Yeah, but look at this, I can make one of these! 'Yeah, right,' she said. And then it sat in my hangar for two or three months before I got enough nerve to go work on it."

Bob Bounds first laid eyes on Fred Keller's Prospector at EAA Oshkosh 1989.

Burn Before Building

Bounds started work with a tape measure, legal pad and Sawzall. Initially, he'd planned to turn his measurements into plans, "but I was spending more time at the drawing board than in the shop." Since he started with the wings, he has some pretty good drawings for them. The fuselage drawings are "mediocre, and the tail surfaces nothing, [but] I still have the templates for cutting the foam."

To figure out the composite layup schedule and orientation he cut fiberglass coupons with the Sawzall and then set fire to them. "This burns all the resin out of them so you can see the layup schedule and orientation." Labeling each structural biopsy—"this is the spar cap"—he'd peel them apart and make more notes.

Making its first flight in 2013, Bearcoupe construction "took seven years," Bounds said. "Life gets in the way, but I just kept chipping away at it and worked on it pretty steady." When he had to crawl over the structure that filled his two-car garage on the diagonal, he built a bigger shop in the backyard "and my wife could have her garage back."

The Bearcoupe, and the Prospectors that preceded it, were built using Rutan-method moldless composite construction. "I didn't vacuum bag anything." Like Bounds, Keller had built a VariEze, which earned a grand champion award at Oshkosh in 1980. Burt Rutan presented the award, and that meeting led to a Defiant opportunity.

Rutan designed the four-place push-pull twin for certification and OEM production. When that didn't happen, in 1981 Rutan asked Keller to build a Defiant from the OEM shop drawings and draft plans for amateur builders. Keller flew the result to Oshkosh in 1983. Fresh from that build, Keller designed the Prospector.

"The greatest challenge in reverse engineering the Prospector wreck was figuring out the sequence of building," said Bounds. "So I built the wings first. After I got them done, I hauled in the pieces of the fuselage and started on that."

He copied the Prospector's wing system (designed specifically for Keller by the renowned John Roncz), which includes slotted flaps and drooping ailerons and the Keller STOL-1 airfoil. The

The fuselage is open from the cockpit all the way to the tail (left), making room for hauling 12-foot-long boards as cargo. The fuel is carried in the leading edges of the wings (right).

The airplane is built using Rutan-method moldless construction.

October 1989 *EAA Sport Aviation* article said the system was mechanically simple and uncomplicated, but Bounds replaced its cables with pushrods because "Couples said there was a lot of slop in it."

With a 34-foot span, the spar in each wing extends more than 3 feet past the root. These spars overlap each other and fit into a structural box behind the seat. "The wings actually sweep forward about 9 inches at the tip, so the spar can go behind your back," he said. "You won't notice it unless you see it from above or below."

Like the Defiant, the wings have "pultruded" spar caps, Bounds said. It's like an I-beam; builders dig out a trough in the foam core between the two fiberglass spar webs and fill it with S-glass

Bounds works on the box that secures the overlapping spars behind the cockpit.

Before long, the Bearcoupe outgrew the two-car garage, so Bounds built a bigger shop in his backyard.

twine pulled four strands at a time. "It takes 6 or 7 hours to fill the trough and then sand it level [once it cures]."

Describing the tool that wets the strands with epoxy, Bounds said he found one through the online Defiant groups. "A guy sent me his and told me to pass it along to the next builder in need because I don't need it anymore."

The flaps are huge, with extra layers of glass on the bottom to protect them from rocks thrown up by the tires and prop blast. Each one measures 8 feet by 14 inches. The ailerons are 6 feet long and droop at a 25% ratio, Bounds said. There are four notches of flaps to 40°, the setting where the ailerons droop 10°.

In converting the controls from cables to pushrods, Bounds decided on a center control stick with rudder pedals and brakes for both seats. He spent a lot of time "sitting at my kitchen table with my old trig book trying to figure out the layout and make it do what I wanted it to do."

The Bearcoupe's fuselage is slightly longer and wider than the Prospector, and the tail is different. "You can make the tail any shape you want," Bounds said. He purposely replaced the original's Cessna 180/185 angular outline with the sinuous profile of a WWII bomber, minus the tail gunner's position.

It's a tribute to the late Ed Martins, friend, homebuilder and aviation mentor. "He was a farm boy who loved flying. A B-17 pilot, he flew 30 missions over Germany and had two DFCs [Distinguished Flying Cross, which recognizes heroism or extraordinary achievement while participating in an aerial flight]. He had some great stories."

Worried about that B-17 tail, Bounds said the CG computations surprised him: "The CG is fine." The inspecting DAR made sure of that. Beyond Bounds's final numbers, "he wanted to see my scratch paper." Fortunately, Bounds had saved all of it.

Apparently, a homebuilt the DAR had inspected crashed because the builder computed the CG using the spinner as the datum, said Bounds. He mistakenly used the main gear number as the datum when he computed the tailwheel figure, which made the airplane dangerously tail heavy. "The DAR was a sharp guy, and by checking my work he was going to make sure that I hadn't made a similar mistake."

Keller designed the Prospector for backcountry operations, including hauling 12-foot boards to his lake cabin outside of Anchorage. They slid into the massive baggage compartment through the cockpit, and Keller designed the CG to accommodate them. It normally wears 8.50 tires, but it can also put on big bush wheels or skis. "The wheel pants are just for running around, like going to Oshkosh," Bounds said. "Nobody makes them, so I had to. I've had a number of guys come up and ask 'where did you get those?'"

With the Bearcoupe complete, Bounds hauls its 3D Prospector plans to the city dump.

A rare 170-hp Lycoming O-340 turns a Catto composite prop.

While sketching a ream of unsatisfactory paint schemes, Bounds saw an ad for the Cessna TTX. "Its paint scheme was better than anything I could do, so I stole it." Before applying the single-stage urethane, he did a lot of sanding. "As homebuilts go, the Bearcoupe is not a small airplane. You fill it, then block it all out, and do it all by hand with long, level sanding blocks to avoid ripples. It's working on your upper body strength."

A Dynon SkyView system with GPS, ADS-B Out and In, and transponder dominates the panel. "All that equipment is remotely mounted behind the rear bulkhead, which makes it handy to work on." A panel-mounted MGL unit handles all the communication and intercom duties. "I installed all of the avionics, and wonder of wonders, it all worked!" said Bounds.

"I have an ancient O-340 in it. Rare birds, Lycoming only made them for about two years," Bounds said. "I think they were made for the twin Navion because it needed more power than the 320 produced, so Lycoming stroked it. Two years after that, they came out with the O-360, and they quit building the 340."

Bounds bought the four-cylinder, 170-horsepower Lycoming used. "It seems to pull the airplane well; I cruise

A center stick divides the wide cockpit, and a Dynon SkyView system dominates the panel.

Bounds, wearing sling, and three friends trailered the Bearcoupe home from Utah after its locked-brake landing (left). Fortunately, Bounds had a spare canopy (right), but he still had to build a frame for it.

at 115 knots and land at about 40." It burns 13 gph wide open in a climb, but lean of peak at 11,000 feet it burns 5.5 gph at cruise. "With 55 gallons of fuel, it gives you enough to go out a bit farther—and get back—without crowding" the reserve.

Originally, the Lycoming turned a metal Sensenich propeller. Then he tried a Catto composite prop and became a fan. "I lost no takeoff performance and gained 10 mph, and it only weighs 13 pounds," he said.

First Flight

The first flight in June 2013 went well, said Bounds. Like many newborn homebuilts, it had some teething problems. The anti-servo tab ratio on its all-flying stabilator was wrong. "If you let go [of the stick] it would diverge, then start getting worse and worse." After making incremental adjustments, "it's stable now, and you can upset it now and it will resume level flight," Bounds said.

"It is the gentlest taildragger I've ever flown. I taxi at 20 knots, looking around, and it just rolls so straight. And it lands slow. I learned from the backcountry guys that the secret to getting into those strips is to get slow early and drag it in a bit. If you come in too fast, you can't get rid of the extra speed, and some of those strips are one-way in and one-way out."

The son of a pilot, Bounds has been an airplane nut since childhood, but he didn't learn to fly until 1983–84, after he met his wife. "Here was this tall, good looking girl, and her dad had an airplane," a Cessna Cardinal that he rented to Bounds "for $25 an hour, wet!"

His instructor was "a starving spray pilot" who'd just started his business. "He got paid by the acre, so my wife basically fed him that winter and he taught me to fly for free. He was death on handling the airplane. We did accelerated stalls and spins and all the stuff you don't have to do [to earn a private pilot certificate]."

Given its STOL missions, the takeoff run isn't long.

The Bearcoupe needed a new cowl (left). The overlarge baggage door doubles as an escape hatch (right).

Completing the Bearcoupe's Phase 1 testing, "I did some backcountry flying hither and yon." On its inaugural visit to Oshkosh in 2014, Bounds earned an Outstanding Workmanship award. "I think that was because I was in a sea of RVs. The judge came by and said, 'I don't know what in hell this thing is, but it ought to win something,'" Bounds said, chuckling. "I was pretty swelled up about that."

A Generally Bad Day

A prudent pilot, when venturing into a new backcountry region, Bounds flies first with an instructor who knows the area. The 13,000-hour CFI he flew with in Hanksville, Utah, "knew his stuff." Returning to the airport, "where I was going to drop him off and get my wife to show her some of the backcountry strips we'd just been to, he asked if he could land," Bounds said.

"My son is tall and has really long feet, so the rudder pedals on the right side are high up and hinge at the top. This guy was short, and he didn't like the way the pedals felt, so he slid his feet up on the brakes. When we touched down, he had the brakes locked and—wham!—we went right over."

The Catto prop "made a few ditches in the berm," said Bounds. "It wasn't broken, so I sent it to Catto, asking them to take a look at it. They asked what happened, and I told them I flipped the airplane and stuffed it in the dirt. After examining it, they said it was OK, so they put new leading edges on it, refinished it, sent it back," and he put it on the Lycoming, which had undergone its own examination.

The rest of the airframe didn't fare so well, he said. "It tore the cowl off, destroyed the canopy, crushed the turtle deck a bit and the tail halfway. One wingtip was caved in, and it was skinned up here and there. The wheels and tires were fine."

With unexpected understatement, Bounds said, "It was, generally, a bad day." The shoulder harness broke

Bounds says the Bearcoupe is an easy-to-fly, straight-tracking taildragger.

The wide cockpit, bubble canopy and forward-swept wings give the pilot an excellent field of view.

BOUNDS BEARCOUPE

Estimated completed price	State secret—uh, maybe $60,000
Estimated build time	7 years, maybe 4000 hrs
Number flying (at press time)	1
Powerplant	Lycoming O-340 170 hp
Propeller	Catto 78x52 composite
Powerplant options	Fuel injection (RSA), electronic ignition (single)

AIRFRAME

Wingspan	34 ft
Fuel capacity	55 gal
Maximum gross weight	2300 lb
Typical empty weight	1320 lb
Typical useful load	980 lb
Full-fuel payload	650 lb
Seating capacity	2
Cabin width	43 in
Baggage capacity	150 lb

PERFORMANCE

Cruise speed	115 kt
Maximum rate of climb	1000 fpm
Stall speed (landing configuration)	40 kt
Stall speed (clean)	48 kt
Takeoff distance	800 ft
Landing distance	800 ft

Specifications and pricing provided by Bob Bounds.

Bounds's left collarbone and arm, "and I'm left handed." Because the instructor evidently didn't get his harness fully latched, he slid forward and broke his neck.

Like the Defiant and Prospector, the Bearcoupe's canopy swings to the side. Hinged on the right, the occupants enter the cockpit by climbing two steps on the left gear leg, sit on the wing and swing their legs into the cockpit.

To provide a way out in case of a rollover, Keller kept the cockpit open above the spar and put an oversize baggage door behind the left wing. This was prescient because Keller flipped the Prospector at Oshkosh 1989 (where it was named grand champion) when an inaccurate fuel sight gauge resulted in a surprised silence during a photo flight that ended upside down in a wheat field.

Bounds didn't have the Keller-designed latch that also opened from the inside, and he wasn't interested in causing more damage by kicking out the

Bob and Deb Bounds, just back from a backcountry trip in the rebuilt Bearcoupe.

baggage door, so he removed the latch with his Leatherman tool.

By the time he'd wiggled out of the baggage door, people were coming to their rescue. They lifted the Bearcoupe by a wingtip and the EMTs in the group carefully extricated the instructor. Located just north of Lake Powell, Bounds said they have an excellent EMT group there because "a lot of visiting desert riders get hurt…and it is 115 miles to the nearest hospital."

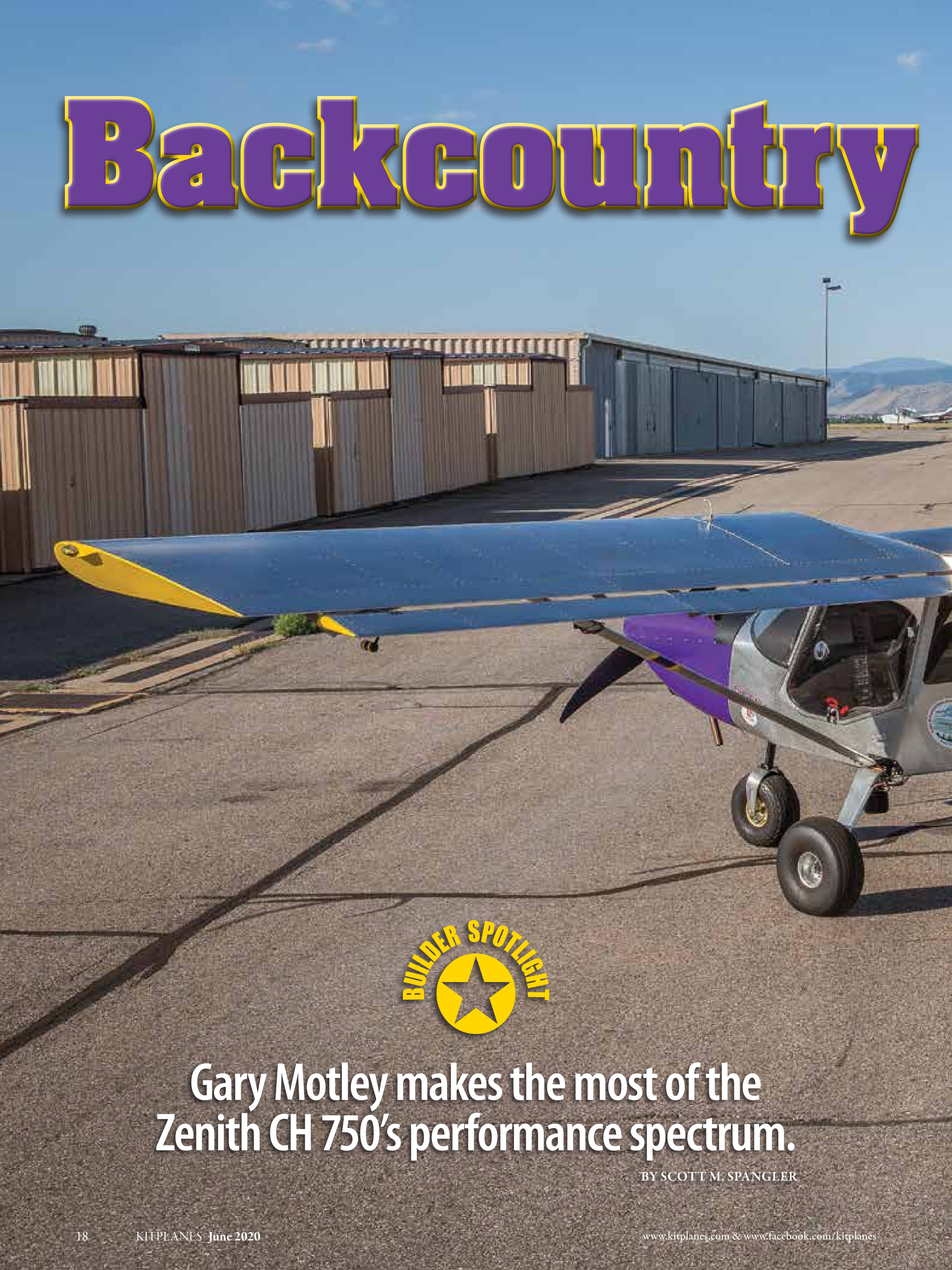
At the hospital, Bounds said he was in a panic. "After getting fixed up, I had to get back and get the airplane off the runway, and I didn't know how I was going to do that in the middle of nowhere. When I got to the airport, the airplane was sitting on the ramp. The nephew of one of the guys ran a crane service, so they went out and flipped it over without doing any more damage to it that I could tell."

After returning home, he and three friends pulled a trailer 600 miles to collect the Bearcoupe. "We put it in the shop and started on it again." His wife was an essential member of the reconstruction crew. "She's a grumpy, really good fiberglasser. I get mad and ready to pull my hair out and throw stuff. And she just stands there, like, OK, when you calm down, let's get going." But she made it clear that "my next wife can help me with my next airplane."

Reconstruction consumed two years, he said, and the hardest parts were the cowling and canopy. "A guy in Florida blew the canopy as a big bubble and then cut it in half," Bounds said. "He sold me the canopy for $500 and offered me the other half for $200, saying it would fit no other airplane. If I wanted it, he said he'd ship it with my canopy, and I said you betcha! So I had a spare canopy sitting in my shop for a couple of years. How's that for lucky? Of course, I still had to make a frame for it."

Since its rebuild, Bounds and his wife have made a number of happy Bearcoupe trips to the backcountry and beyond. And every trip recreates the miracle of the Bearcoupe's first flight and the ineffable joy that its unusual gestation worked out OK. ✈

Backcountry



BUILDER SPOTLIGHT

Gary Motley makes the most of the Zenith CH 750's performance spectrum.

BY SCOTT M. SPANGLER

Cruzer

Every amateur-built airplane tells a story about its creator, and the most interesting are the result of dissonant prognostication, attributes seemingly in conflict. With its bright purple cowl and sunshine spinner, a bare metal Zenith Cruzer stands out in the regimented grid of the homebuilt campground at EAA AirVenture. Its story doesn't get interesting until you are nose-to-nose with the goggle-eyed Minion windshield shade.

Introduced at Sun 'n Fun 2013, Zenith Aircraft's Cruzer is the speedy, cross-country cousin of its light-sport utility airplane, the STOL CH 750. They share the same two side-by-side seats, but a single strut supports the Cruzer's wings, which don't wear the STOL's leading-edge slats. Walk around and you'll discover a vertical fin and rudder rather than an all-moving yaw control and a clipped-span horizontal stabilizer with a symmetrical airfoil. Tiny 5.00x5 rollers wear streamlined spats.

So why does this Cruzer stand tall on three large, naked rubber donuts?

Stickers on its bare metal offer some clues. Behind the pilot's door is the large logo of the Recreational Aviation Foundation, a group dedicated to protecting, preserving,

Photos: Scott M. Spangler and Gary Motley and promoting recreational backcountry airstrips. Another sticker suggests that KBJC, the Rocky Mountain Metropolitan Airport, is the Cruzer's home.

On the vertical fin, a sticker with Colorado's sunny C logo nestled in the mountains supports the airplane's home state. Above it is the black silhouette of a winged dragon. Or maybe it is a stylized Phoenix, the name of the endlessly reborn bird spelled out in yellow-trimmed purple letters just aft of the cowl and above a sticker for ULPower.

The prop card confirmed these prognostications and connected me to the Cruzer's creator, Gary Motley, to explain its dissonance.

Motley powers up his touchscreen Dynon avionics suite.

Subjective STOL

Motley is an avuncular registered nurse who, after 15 years in the ER and ICU, moved to Colorado in 1993, where he's provided metropolitan Denver with home healthcare for the past quarter century. And he's adapted to the mile-high performance penalties.

Zenith says a 1320-pound light-sport Cruzer needs 350 feet to take off and land. At sea level, with 75-percent power, it cruises at 118 mph. At the same weight, the STOL CH 750 needs 100 feet to take off, 125 feet to land, and its maximum cruise speed is 100 mph. "Up here, with two people, full fuel, and 6,000-foot density altitude, I'm usually off in 800 feet or less," said Motley. "I consider that STOL. It's as good as the Maule I had. All homebuilts are individualized. I wanted a utility airplane that meets my needs; that's why I have big wheels and an autopilot. It has no idiosyncrasies, no quirks, and the visibility is outstanding. I go low and slow, so I can put on the autopilot and watch the sights go by during long cross-country trips."

The Cruzer started flying with naked tiny tires ("I don't like wheel pants," Motley says), but then he had to power through the mud fest at the Flying M Ranch Fly-in and Campout in Reklaw, Texas. He attends almost every year, and it rained a lot in 2018, he said. "They used a tractor to haul out RVs with gummed-out wheel pants." Motley replaced his 5-inch rims with 6-inchers and mounted medium-size tundra tires, an 8.00x6 on the nose and 8.00x21-6 on the mains. "That paid dividends at Oshkosh this year [2019]. We had just parked at Fond du Lac when we got the message that if you have tundra tires, come on in [to the rain-soggy field]."

A pilot since 1985, Motley supported his "passions and addictions," as a part-time flight instructor. In 1995, "I snagged a Maule MX-7-160 for a rock-bottom price of $60,000," he said, explaining that Maule periodically built a small block of hybrid airplanes as sales promotions. With a 160-hp Lycoming O-320 mounted to a four-seat M-6 fuselage and M-5 wings, "I flew it for nine years, from coast to coast, and put a little more than 900 hours on it."

Starting his aviation life with model airplanes, Motley always wanted to build full scale, so after selling the Maule he went shopping at Oshkosh in 2007. Originally looking at RANS, he stumbled across the Sonex. He judged

With its bright purple cowl, sunshine spinner and big backcountry tires, this Cruzer had a story to tell.

The Cruzer's high-wing design provides good ground clearance. The tail cone angles sharply up to permit high AOA during takeoff and landing.

its construction techniques within his capabilities. And the airplane "was positive-G-rated for aerobatics and I thought, 'Ohhh, that could be fun!' "

This was before Sonex kits were match-hole drilled, Motley said, and construction took three and a half years. "I was hoping that the power-to-weight ratio would be comparable to my Maule. It was 1200 pounds with 160 hp and the Sonex weighed 600 pounds with its 80 hp AeroVee engine. The mass was pretty close, but the wing planform was not."

Standing a trim 5-foot-10, Motley discovered that the Sonex's dual sticks would not do him any good at Denver's density altitude, so he replaced them with a single stick. "I flew it as a big bubba single-place plane," he said. "The performance was still marginal, but I got everywhere I wanted to go, often crossing the Continental Divide." In 2014, he went to Key West with a stop at Sun 'n Fun.

After six years and 600 hours, Motley needed a roomier, more powerful airplane with backcountry capabilities. After being together quite a while, Motley married in 2015. "Natalia is taller than I am, and putting her in the Sonex was just too tight."

Looking at buildable airplanes, the Maule guided his decision: high wing, side-by-side, lots of cargo space. After putting bigger tires on his Maule, he said, "I enjoyed camping and tooling around the backcountry strips in Idaho and Montana, and I was looking forward to getting back to that." The Cruzer gives him all those capabilities along with great visibility, easy cockpit access and matched-hole, self-jigging construction. Motley discovered the Cruzer at Sun 'n Fun, stopping on his Sonex adventure to Key West. "I got Natalia to go with me to Oshkosh that year and had her sit in it. She said, 'Oh! This is nice.' That was my go-ahead, so I ordered the tail kit."

Meeting the light-sport requirements was another deciding factor. It took Motley more than six months to overcome a nebulous lab value with a special-issuance medical certificate. "There's no disease, no treatments, and my internist kept sending letters to the FAA explaining that I'm not sick. When I got the special issuance, I went Sport Pilot so I don't have to mess with special issuance."

With a HOTAS system on the Y stick, Motley can switch coms, disconnect the autopilot, IDENT the transponder and adjust the Cruzer's pitch trim.

Beyond LSA

BasicMed freed him from Sport Pilot's limitations and the need to build to LSA specs. "I have a fat Cruzer," he said. "I loaded that puppy up with upholstery, carpeting, soundproofing, and some stringers on the fuselage panels to reduce oil canning. I put in dual coms and a full Dynon suite with 10-inch touchscreen

Vortex generators on the wings' leading edges enhance performance and handling.

display, an ILS/VOR system, dual-axis autopilot, Sirius XM radio and a couple of cup holders." Dynon was upfront about its intercom integration with dual coms, Motley said. "It worked, but not as well as the PS Engineering audio panel. I put a HOTAS [hands-on throttle and stick] system so I can flip between the coms, disconnect the autopilot, transponder ident, control elevator trim and, of course, a PTT switch."

With a primary wiring harness from SteinAir, Motley installed the avionics. Most of the boxes are remotely mounted, so he cut another access panel in the belly, just aft of the one under the baggage area, where the torque tubes connect the stick to the flaperons. "If I disconnect the control cables, I can stand up to work on the avionics, fuel pumps, filters, and other stuff. This also gave me a short cable run to the antennas," he said.

"It's amazing how much wire it takes." In total, the avionics added 40 pounds. On the scale, Motley's Cruzer registers 900 pounds when empty. Zenith publishes a max gross of 1440 pounds at 6 G's. Working with the inspecting DAR, Motley derated the plane to increase its maximum gross weight. Dropping to 5.4 G's gave him another 160 pounds without exceeding the published maximum structural limit. After a few years of aerobatics in his Sonex, he cannot think of an on-purpose situation that would get anywhere near 5 G's.

Being a new kit, it took a while to get it; construction started in early 2016. He really wanted the wing kit next, but Zenith did the fuselage first, said Motley. "I like to build the tail, wings and then the fuselage because working in a two-car garage, it's easier to put flat things out of the way. Once the fuselage is in place, you're pretty much stuck."

Zenith's matched-hole kit really impressed Motley. "If you need a 2-inch piece of L angle, it's already been cut and labeled. It's not difficult to figure out." The Cruzer made its first flight on September 30, 2017. "My wife and a friend who helped me with the long-arm stuff during construction were there, and it went well, with no significant issues," he said.

"Stall speed depends on the weight. It's in the mid-40s [mph] solo and high 50s with a passenger." Like his Maule, he installed vortex generators on the Cruzer's wings. His flight tests demonstrated some remarkable deck angles on power, up to 21°, he said. "It now has much better flaperon authority, and the real stall speed may have decreased about 2 mph. Now it just mushes during stall approach unless a vertical sheer comes along to stall the aircraft."

Rebuilding the Phoenix

Motley said the tail graphic was, indeed, a stylized Phoenix, and it is flying over Colorado's mountains. He found the graphics online and had a shop make them to the desired size. But why a Phoenix?

It's a long story, he said, but the short answer is that he had to land in a field after his engine seized on a Phase I flight test. "The landing was great. But there was the barbwire fence I did not notice at altitude. Rolling into it and one of its posts crumpled the front gear leg, the cowl, and the prop and significantly damaged a strut."

For space reasons, Motley hoped to build the wings before the fuselage, but that kit arrived first (left). SteinAir provided the wiring harness for the Cruzer's Dynon avionics suite (center). Motley said the wiring harness and avionics weighed 40 pounds (right).

The Cruzer, after it ran into a barbwire fence (left) on its way back to the airport after the original engine quit in flight, leading to a forced landing. To prevent injuries, barber pole markings warn passengers of pointy door edges (right).

The engine at that point was the Viking, based on the liquid-cooled, direct-injected Honda Fit engine. Motley followed the Viking for a number of years through posts on Zenith sites. "There was no real negative stuff being reported on it," he said, so when he had to make an engine decision, he essentially flipped a coin because the "engine costs about half the price of anything else we can do."

After the initial installation, instead of starting, the Viking would blow its starter fuse. Viking said another builder was having the same problem, adding that it needed to update its wiring diagram. "The engine comes prewired with the ECU [engine control unit] and wiring harness," said Motley. "You connect the positive and negative and run it through a fuse. So we redid the starter wire, put in a bigger fuse and still couldn't get started unless I cranked it and cranked it. I called again, and the company said you'll never get it started unless you inject starter fluid in the throttle body, and I got that in print."

Motley finally got the Viking to run, but it would die when he reduced power. During an online session with the ECU's vendor, it looked like it wasn't producing enough fuel pressure. "My engine, the 130, is direct gas injection. It has its own mechanical pump mounted to the engine that goes from 40 to 2200 psi, and it is not constant delivery. It has a solenoid that has to be timed to the injectors."

After Viking sent several ECUs with different programming and not getting reliable power, Motley removed the engine and returned it. When he got the engine back, it still would not start. Knowing that fuel pressure had a role in this drama, Motley installed a stock Honda fuel pump, and the engine started instantly. An air/fuel meter said it was running lean, but Viking said, "Don't worry about it because you won't be running at those settings."

Motley started his Phase I testing with short flights of an hour or less. "About 10 hours in, I did a 2-hour flight in the pattern, and when I pulled the power back on final, the engine died. Coasting, it started sputtering as I flared; then it started and stopped

On landing, the Cruzer needs only 800 feet of running room for a comfortable arrival.

ZENITH CRUZER N956GM

Kit price	$24,790
Completed price	$60,000
Estimated build time	300-500 hr
Number flying (at press time)	75
Powerplant	ULPower 350iS
Propeller	Sensenich 68-in. two-blade
Powerplant options	O-200, O-235, Jabiru, Rotax 912, Aeromomentum, Viking

AIRFRAME

Wingspan	29 ft 9 in
Wing loading	11.1 lb/sq ft
Fuel capacity	30 gal
Maximum gross weight	1600 lb
Empty weight	900 lb
Typical useful load	700 lb
Full-fuel payload	520 lb
Seating capacity	2
Cabin width/with bubble doors	42/50 in
Baggage capacity	120 lb

PERFORMANCE

Cruise speed	100 mph
Maximum rate of climb	1000 fpm
Stall speed (landing configuration)	48 mph
Stall speed (clean)	54 mph
Takeoff distance (6000 ft density alt)	800 ft
Landing distance (6000 ft density alt)	800 ft

Specifications and pricing provided by the builder.

The ULPower engine turns a ground-adjustable Sensenich prop. Medium-size tundra tires work well in the backcountry, and LED lights illuminate the way.

again all the way back to the hangar." Five Viking ECU updates later, flying out to the test area, "alarms go off, the temperature spikes, and the engine overheats." Making an immediate 180° turn back to the airport, Motley says the engine lasted about 30 seconds before seizing. With a mixture of oil and coolant in the cylinders, "my theory is that it got so hot from being so lean that it separated the head gasket. The pressure in the cylinders blew all of my coolant overboard through the overflow bottle."

Take Two

That was enough for Motley, and so he replaced the Viking with a 130-hp ULPower 350iS four-cylinder, air-cooled, FADEC-controlled engine. "I always liked ULPower. It's kinda pricey, but it looks great, CNC'd in Belgium, with a lot of redundant features." When there's a problem, a warning light glows and the engine defaults seamlessly to a richer mixture. When the light went on, Motley noted that his fuel flow increased 0.6 gph. Two 14-gallon wing tanks, working through a 2-gallon header tank, feed the engine, which consumes about 6 gph in normal cruise flight.

After receiving a loaner, Motley sent his ECU to Belgium. "Sure enough they found a software bug," he said, adding that ULPower said it was recalling about 10 other ECUs for updates. Installing the updated ECU just before AirVenture 2018, he's had "no light, no problems" in the 250 hours he logged before heading to Oshkosh in 2019.

A two-blade, ground-adjustable Sensenich prop turns ULPower into thrust. Motley had a custom pitch pin ground to give him a finer pitch in Denver's density altitude. (The Sensenich

With remotely mounted avionics, there is a short cable run to their antennas (left). On the wings are the vented caps for the two 14-gallon tanks. Just ahead of the belly antennas is the second access panel (right) that allows Motley to stand up in the avionics bay.

To save his knees, Motley has a unique tug.

system uses a precision pin inserted into the hub that contacts lateral pins on the blade bases. The diameter of the pin determines how much pitch each blade has. The smaller the pin, the finer the pitch.) "It is such an easy system. I can land somewhere, repitch it, fly around the backcountry, repitch it again and leave," he said.

Changing engines didn't adversely affect the Cruzer's center of gravity, but removing the heavier Viking engine left a large space between the engine and firewall. After checking his weight and balance calculations with several A&Ps, Motley built a small box in the space "for the 20 pounds of stuff you normally carry everywhere—oil, tie-downs, tools. That 20 pounds up front gives me about 50 pounds more in the back."

Pain and Paint

Before running into the barbwire fence, Motley had planned on a professional paint job. Afterward, he just wanted to fly. When ULPower took him to Oshkosh in 2018, "I put big-ass Band-Aids all over where it was damaged and added a Humpty-Dumpty sticker." Deciding he could better invest the cost of a pro paint job, he kept it simple.

During this adventure, Motley named his Cruzer Phoenix, and it's been living up to its namesake. Another builder in the Cruzer community reported a crack in his horizontal tail's leading edge. A month later, "after a long flight to Bryce Canyon, I found the same fracture pattern on the opposite end." Communicating with Zenith and sending photos and a deconstruction video, the company re-engineered it, published a service bulletin and changed the kit. Later, when giving a friend a ride, on final approach the Dynon display "just started rebooting over and over again," he said. "It got locked in that cycle. Then it displayed a splash screen that said if it continues, send it to Dynon. They did about $500 worth of warranty work on it."

Since then, Motley said the Phoenix has been behaving. And he is eagerly looking forward to his backcountry camping trips.

Mounted in the elevator, an electric servo actuates a trim tab (left). While the Cruzer does not have the STOL 750's leading-edge slats, it retains the underslung flaperon control surfaces (right) for roll and additional lift at low speed.

BUYING USED:

Kitfox

A pair of nice Kitfox Series 7 Super Sports on the lake bed at the 2019 High Sierra Fly-in. *(Photo: Brian O'Neil)*

Always in high demand, be ready to act fast when you find one you like.

BY LEROY COOK

Photos: Paul Bertorelli and Richard VanderMeulen


The Kitfox is perfect for low-and-slow flying over the countryside.

If you're looking for a light, fun-flying airplane, you'll almost certainly want to consider the Kitfox. This iconic little taildragger has been around since 1984, when the original versions were introduced as a step-up from the Part 103 ultralight "vehicles" whose popularity had already begun to fade by the mid 1980s. Providing side-by-side seating for two in an enclosed cabin, the Kitfox offered respectable comfort, speed, short takeoff and landing performance and all-around utility, wrapped up in a sharp-looking package. At this point, over 7000 Kitfox kits have been produced, so one might expect potential for a plentiful supply of used Kitfoxes in the marketplace. You'd be wrong.

That 35-year production run doesn't necessarily translate into a buyer's market. John McBean, president of Kitfox Aircraft, says there are very few Kitfoxes for sale; most owners don't want to give them up unless circumstances dictate. That's not just a pitch to sell new kits, but rather the common opinion shared by most owners we spoke with. Kitfox builder Josh Esser told us, "You better have your money ready" if you're looking to buy one, because the two late-model used Kitfoxes he bought after building his own weren't even advertised when he heard they were available, and he knew he had to put down a deposit right away. As is typical of desirable used airplanes, the good ones don't last.

History

Orginally designed by Dan Denney, the first Kitfoxes were powered by the then-popular two-stroke Rotax 532 and 582 engines of 64 hp. The Kitfox's distinctive bump cowling, which gave it the look of a miniature Cessna 195, dates from 1986; originally, a small Pong Dragon radial engine was planned for the airplane, but that engine never worked out. A wise marketing move retained the cute round-engine wrapper. Adapted for various powerplants over the years, it continues to be available.

From its beginning as the Kitfox Model I, of which only 257 kits were sold, the design underwent a steady progression of improvements as engine power and gross weight were increased. The Model I had a gross weight of 850 pounds, while the slightly larger Model II, introduced in 1989, had a bigger vertical tail and grossed at 950 pounds; 490 Model II kits were sold. A Model III came along in 1990 with further enlargement of the tail feathers and a gross weight bump to 1050 pounds, allowing installation of the


The Kitfox's chrome-moly frame can be powder-coated for corrosion protection.

A glassed-in turtle deck/baggage area brings light into the cabin and adds to the perceived spaciousness of the Kitfox.

80-hp Rotax 912 four-stroke engine; some 466 Model III kits were shipped. The definitive Model IV came out in 1991, featuring a new airfoil and redesigned differential-action flaperons that were mounted with metal brackets instead of wood attachments; 322 kits were sold before a follow-on Classic IV version increased the gross weight to 1200 pounds. The IV-1200 incorporated stronger lift struts, beef-ups for the gear legs and wing carry-through, fuselage structural changes and a 30% larger vertical tail. The Kitfox Classic

This older Model IV has the classic Kitfox bump cowling and is powered by an 80-hp Jabiru 2200. *(Photo: Amy Laboda)*

Scott Noble's Kitfox 7 Super Sport

Owner Feedback

Scott Noble

"In 2012 I ordered my Kitfox S7 Super Sport. Six months later, my kit arrived and I started my Kitfox adventure. After one year and four months, I made my first flight. The build was fun, but my flying adventures have been even more exciting. I've taken my Kitfox all over the Northwest, landing on river bars and backcountry strips. The Kitfox is a great backcountry plane with a broad flight envelope and great load-carrying capacity. My favorite mission is to load up my camping gear and head to the Idaho backcountry. Last spring I took a trip to southern Utah, landing at Happy Canyon, one of many strips to explore in the area. My Kitfox easily hauls full fuel, two people and all the camping gear that I have needed. Some planes can fly slower or fly faster, but it would be hard to find another plane that efficiently beats the broad flight envelope of a Kitfox. My plane stalls at 36 mph and cruises at 118 mph with a 100-hp engine burning 4 gallons per hour.

"I would find it hard to part with my Kitfox, but some planes do come up for sale, then sell quickly. With social media, a broader audience is seeing the value in Kitfox aircraft. Log onto *www.TeamKitfox.com* and start reading the new threads for a while, and you will get a feel for the Kitfox community. It is a fantastic part of owning a Kitfox. You will be surprised at the help offered by members of this community. You may even be able to buy a used Kitfox if you ask the question."

Shawn Hoenshell

Shawn Hoenshell of Peculiar, Missouri, is just now finishing up his Kitfox Model IV project, and he's looking forward to trailering it around the country for low-and-slow sightseeing wherever his travels take him. He has enjoyed the project, finding it straightforward in most regards. He discovered a rudder pedal beef-up service bulletin that needed compliance, something that should be checked if considering purchasing an early SkyStar-supplied Kitfox. He also found that a different material was used in the later-production fiberglass fuel tanks to better tolerate auto fuel with alcohol content. His kit's tanks are only recommended for no-ethanol fuel.

Raymond Peters

Raymond Peters of Bayfield, Wisconsin, has owned his nice 1989-built Kitfox Model I since 2009 and considers it a great little single-person airplane. "The Model I fuselage is a little narrow for two people," he says, but he's added a window ledge/armrest that makes it more comfortable. After a landing gear bungee cord broke due to its age, he installed the wider spring gear rather than replace the shock cords, and he also installed hydraulic brakes for better handling. Peters favors four-stroke engines over two-stroke ones, and his plane is fitted with a 62-hp KFM-112 four-cylinder engine from Italy (no longer in production) that he has been very satisfied with. His Kitfox was built with two wing tanks rather than the single header tank, giving it plenty of endurance.

Brian O'Neil's Kitfox Series 7 near the Grand Tetons. *(Photo: Scott Noble)*

The clipped-wing Speedster is the fastest Kitfox. This one is a Series 7, but there are earlier versions of the Speedster, too. *(Photo: Courtesy of Kitfox Aircraft)*

Owner Feedback

Brian O'Neil

"The first piece of information I can share regarding buying a used Kitfox is one you'll probably hear from several sources. The market is very hot, so you'll need to be ready to move on a purchase. Sellers don't need to accommodate buyers' demands right now. You can't wait to find the right plane before you figure out how you're going to pull the cash together and arrange a prebuy inspection. You would do well to have someone on standby who's qualified to perform a prebuy inspection, ready to go take a look as soon as you see something on the market you like.

"The second piece of information I'll share is that when you buy a Kitfox, whether a kit or a used aircraft, you buy into an amazing community. I'm convinced that no other airplane brings people together like the Kitfox. The level of support you'll get from the factory and other builders/owners is second to none."

Steve Kellander

Steve Kellander (right) with DAR Ted DeSantis.

"I own *www.TeamKitfox.com*, a forum-based website for Kitfox builders and owners to come together and share building tips and travel adventures, and sell and buy parts, kits and completed Kitfox aircraft to other enthusiasts. Since its inception in 2008, the main focus of the forum has been to promote the building of safer aircraft and pilots. With almost 7500 registered members and growing every day, it is the best online place to find answers to questions about every model of Kitfox from the Model I through the current Series 7 Super Sport. It is a great resource for new Kitfox enthusiasts to educate themselves on any model they may have an interest in.

"I have been flying Kitfoxes since purchasing my first, a Model III, back in 1998. Since then I have built two: a Model IV and a Series 7 Super Sport that I just completed. If you are not educated enough to scrutinize build quality on the Kitfox model you are considering purchasing, take along someone who is."

Frank Julian

Frank Julian of Kansas City, Missouri, built his Kitfox Model IV in 1997 and considers it "a perfect little airplane." He still has the Rotax 582 oil-injected two-stroke engine in his IV, which has proven to be entirely satisfactory for his purposes.

IV remained in production until just recently, giving it one of the longest production runs in kit airplane history.

Denney Aerocraft sold the Kitfox design to SkyStar Aircraft Corporation in 1992, setting off a flurry of new model developments. A Kitfox Series 5 design came out soon after the SkyStar acquisition, featuring an adjustable stabilizer for pitch trim and optional aluminum-spring landing gear. The Series 5 was available in a tricycle-gear, swept-tail Vixen model or a conventional-gear Safari version, both designed to accept small Continental and Lycoming engines at a gross weight of 1400 pounds, later boosted to 1550 pounds in 1995. In 1998, the names of the Series 5's two versions were changed to Voyager and Outback. A short-wing Series 5 Speedster variant was tried as well.

Meanwhile, SkyStar tried producing a Part-103 ultralight, the Kitfox Lite, using a 28-hp two-stroke engine, and it also introduced a Kitfox XL in 1994 and a Kitfox Lite Squared in 2001; both were two-seaters designed to be ultralight trainers, using a 50-hp Rotax 503 two-stroke engine. A Kitfox Series 6 was brought out in 2000, with a conventional cowling rather than the faux radial engine nose and featuring standard spring main gear rather than bungee shock absorbing. A Kitfox Series 7 followed in 2002, incorporating a larger elevator and improved roll control. The

The latest Kitfoxes can be switched from tricycle to conventional landing gear and back again. In either configuration, the visibility is outstanding.

Kitfox Series 6 and 7 offer convertible landing gear configuration that can be switched from tailwheel to nosewheel and back, if desired.

Kitfoxes have always called southwestern Idaho home, in the area around Boise; the plant was originally sited at Nampa and is now located at Homedale's airport. In April 2006 the rights to the Kitfox designs were purchased by John and Debra McBean, who are the current owners of Kitfox Aircraft, LLC. Production is now primarily focused on the Series 7 designs, with the Kitfox Classic IV presently on hold.

Design

There is a vast difference between the Kitfox airplanes of the 1980s and the kits designed in the last 20 years. Some seekers of used Kitfox airplanes have in mind one of the original designs, a diminutive fabric-covered tailwheel airplane with the bump cowl, Junkers-style external flaperons, folding wings and bungee-sprung landing gear. While the basic design features remain, the more recent, sleeker Series 5, 6 and 7 Kitfoxes are much more capable airplanes. The structure of the fuselage, tail and lift struts is made of 4130 chrome-moly steel, factory welded, while the ladder-style wings incorporate 6061-T6 tubular aluminum spars reinforced by an aluminum I-beam insert, with the airfoil shaped by wooden ribs. The trademark external flaperons are built of aluminum-wrapped foam cores or ribs. All Kitfoxes feature foldable wings for compact storage or trailering. Flaperon and elevator controls utilize 4130 steel pushrods, while the rudder is cable actuated.

A powder-coated fuselage frame became available in the early 1990s, which forestalled much of the corrosion threat of aging steel. The Kitfox's small-diameter tubing did not lend itself to the sloshing of anti-corrosion oil through the framework because each section of tubing was sealed off from its mates. The earliest Kitfoxes had aluminum firewalls, rather than stainless steel.

As with most light airplane designs, the Kitfox has evolved into ever-improved iterations over the years. Accordingly, you should look for the latest example you can find, and it's important to

Even VFR Kitfoxes (left) can have plenty of electronics to make flying easier. The latest Kitfox cabins (right) have plenty of space to carry two in comfort.

bear in mind the condition issues that could be wrought by 20 to 30 years of history. The Series 5, 6 and 7 are the best choices, with a cabin width of 43 inches. If considering the older models, I wouldn't advise looking any further back than the Model IV-1200, because of its increased useful load, differential-action flaperons and larger tail. If you have limited or no tailwheel airplane experience, look for a Kitfox that has dual brakes installed, which makes tail-wheel instruction much less risky.

The flying characteristics of the Kitfox series are typical of airplanes in its weight class; John McBean says his Series 7 can "take on crosswinds that would leave Cessnas crying." That said, the older airplanes, weighing less than 1000 pounds, are susceptible to even the lightest breezes and subtle wafts of updrafts and downdrafts. Penetration of turbulent air is not on par with more streamlined and heavier airplanes, calling for ultralight-style flying technique during a landing approach, which means maintaining some energy in the aircraft by carrying power right down to ground level and staying ready to go around if the wind burbles become unmanageable. Fortunately, it's usually easy to find a 500-foot long patch of friendly grass oriented into the wind, which makes much more sense than trying to stick an early Kitfox onto an unyielding strip of pavement contaminated by crosswind component.

Assuming an 80-hp Rotax 912 engine installation, the Kitfox is a good 100-mph-plus cruiser, with a stall speed

Bubble doors on an S7, but also an option on earlier models, open up the cabin and provide a little extra shoulder room.

Kitfox Through the Years

Denney Aerocraft produced the first Kitfox kit in November, 1984. Since then, over 7000 Kitfox kits have been shipped to builders in more than 40 countries. Here are the highlights of the different models.

Model I

Designed by Dan Denney, the original Kitfox Model I is a lightweight, two-place aircraft with a gross weight of 850 pounds, typical empty weight of 426 pounds, and typical useful load of 424 pounds. Usually powered by a 64-hp Rotax 532, the Model I cruises at 65 knots and stalls at 31 knots.

From a flying standpoint, the Model I feels very similar to an ultralight. Controls are light and the rudder exhibits a neutral yaw condition; if you push the rudder to yaw the plane, it will stay yawed. You usually have to move the rudder with your feet to bring the nose back to center.

Model II

Introduced in 1989, the Kitfox Model II is a bit faster and stronger than the Model I. The spars were strengthened, allowing an increase in gross weight to 950 pounds. Typical empty weight remained at 426 pounds, resulting in a useful load of 524 pounds.

Flying-wise, the Model II feels quite similar to the Model I, even though the vertical tail surfaces were enlarged to accommodate wing tanks and the Rotax 582 engine. Average cruise increased to 74 knots and stall speed remained at 31 knots.

Model III

With the Model III, introduced in 1990, structural changes allowed builders to use larger engines, including the 80-hp Rotax 912. Once again, in an attempt to improve the yaw control issue, the vertical stab and rudder were enlarged. Other structural changes included larger, stronger lift struts and spar carry-through tubes.

Gross weight of the Model III increased to 1050 pounds, with an empty weight of 460 pounds and a useful load of 590 pounds. Average cruise speed remained at 74 knots, and stall speed increased ever so slightly to 32 knots. Handling characteristics are similar to earlier Kitfox models.

Model IV-1050

Introduced at Oshkosh in 1991, the Model IV was a completely new aircraft. It features a higher-speed, laminar-flow airfoil, an updated flaperon design and a completely different aileron system that improves control with full flaps and reduces adverse yaw.

The vertical fin area remained the same as the Model III, but it was still too small. While yaw stability was no longer neutral, it was not aggressively positive. Gross weight is 1050 pounds, the same as the Model III.

Model IV-1200 (Classic IV)

Also introduced in 1991, the Model IV-1200 was the final evolution of the original Kitfox design. Heavier lift struts, gear legs and spar carry-through tubes allow a 150-pound increase in gross weight, to 1200 pounds. Empty weight is typically 650 pounds, with a 550-pound useful load. Cruise speed varies with engine, but is typically around 95 knots. Stall speed is 32 knots.

On the Model IV-1200, the height of the vertical stab and rudder was increased 10 inches, and the rudder depth was increased by 2 inches, finally bringing yaw stability to a contemporary feel.

With its high-lift STOL wing, 180-hp Titan 340 engine and 29-inch Alaskan Bushwheels, the S7 STi is a highly capable backcountry performer. *(Photo: Paul Dye)*

as low as 32 mph that enables short takeoff and landing distances. As always, engine/propeller configuration and setup can cause variations in performance numbers from builder to builder. The wing area of 132 square feet gives a wing loading of only about 9 pounds per square foot. Wingspan is 32 feet, overall length is 18.5 feet, and the three-point tail height is just under 6 feet. Even without wing folding, required storage space is relatively small.

What to Look For

If purchasing a flying Kitfox, as with any E/A-B airplane, look for complete paperwork, including a log of Phase 1 flying time and the airplane's operating limitations that were issued at the time of certification. The latter is required to be on board for flight. Evidence of a condition inspection within the last 12 months will be necessary, or one will have to be performed before the airplane can fly.

John McBean says the most important advice he gives is to get the serial number of the airplane and check it out by contacting the factory to make sure you know what you're getting. He cites examples of a purported Model IV-1200 (according to its builder-supplied ID plate) that was actually a 1050-pound version and a Kitfox Model III that was being sold, with modifications, as a Model IV. He stresses to get the builder's manual with the airplane, and if it's been lost, to obtain one from the factory. When you call the factory for assistance, it helps immensely to

Series 5

In June, 1992, SkyStar Aircraft Corporation purchased the rights to produce the Kitfox from Denney Aerocraft. Almost immediately, the company began work on a larger version of the Kitfox that would be able to use Continental and Lycoming engines, in addition to the Rotax 912 series.

Although it looks similar to a Model IV, the Series 5 is a totally different clean-sheet design. It's not just a modified IV. Available with either tailwheel or tricycle gear, it had a gross weight of 1400 pounds when it was first introduced in 1994. This was increased to 1550 pounds in 1995.

Cabin width for the Series 5 is 43 inches. Yaw stability is positive, and handling characteristics feel similar to a certified aircraft. That's to be expected, since the Series 5 was actually designed to meet Primary Aircraft certification standards.

Series 6

In January, 2000, work began on the Series 6. Essentially a refined Series 5, the Series 6 has a heavy-duty landing gear that replaces the bungee/tube gear used on the Series 5. The flap system was also improved. The Series 6 has a useful load of up to 800 pounds and cruises at about 104 knots.

Series 7

Since April, 2006, Kitfox Aircraft LLC has held the rights to the design. The latest version is the Series 7 Super Sport, which is available as a kit or ready-to-fly SLSA.

Firewall-forward packages are offered for all Rotax 912 series engines and the 915 iS, Lycoming's IO-233 and O-235, Continental's O-200, IO-240 and Titan X340, and the Jabiru 3300. There's also a radial engine that fits under the round bump cowl: the 7-cylinder, 110-hp Rotec R2800.

The Series 7 easily converts from tricycle gear to taildragger and vice versa. Like all Kitfox aircraft, it has folding wings.

S7 STi

The S7 STi is a "STOL inspired" version of the S7 Super Sport. The key difference is a modified wing featuring vortex generators, mid-wing fences, wingtips with fences, and greater wing area. The end result is a substantial increase in short-field performance.

With the 180-hp Titan X340, takeoff and landing roll are typically 100–150 feet, rate of climb is over 2000 fpm and stall speed is 32 mph. Cruise speed is as much as 127 mph, but this will vary depending on prop pitch.

By comparison, the standard S7 Super Sport with a 100-hp Rotax has a 290-foot takeoff roll, 270-foot landing roll and 1000-fpm climb rate. Stall speed is 41 mph, and cruise speed is 120 mph.

S7 Speedster

As its name implies, the Speedster is the go-fast member of the S7 family. With its clipped wing and streamlined wing struts, landing gear and wheel fairings, cruise speed is 130 mph with a 100-hp Rotax 912 iS. Climb rate is over 1200 fpm, and stall speed is 47 mph.

— Mark Schrimmer

have the manual's references for the items under discussion, rather than saying "I need that widget that moves the aileron (flaperon)."

Engine Options

The earliest Kitfoxes were most likely to have been fitted with two-stroke Rotaxes, and as the design matured into the Model III and IV the four-stroke Rotax 912 became the engine of choice. Other lightweight engines used have been the Jabiru, Subaru, and a whole host of similar engines have found their way onto the noses of Kitfoxes. The newer Series 7 Super Sport can be fitted with a Rotax 912ULS, turbocharged Rotax 914/915, Continental O-200, Lycoming O-233 or Titan O-340. Even the Rotec R-2800 radial has been grafted onto the Kitfox Series 7, with a nod to the original cowling design.

Values

Given the scarcity of available used Kitfox airplanes, pricing will be subject to the seller's eagerness to dispose of their plane. Expect to pay $100,000 or more for a nice Series 6 or later, down to as little as $20,000 for an old Model I or II that's still flyable but needs TLC. It follows, as always, that you get what you pay for, based on condition, equipment and history.

The Rotax 9-series engine is the most popular choice for Kitfox builders.

Support

Fortunately, the Kitfoxes are not orphans. According to John McBean, factory support is available for all Kitfox models, as much as possible. However, through the years and ownership changes, some tooling and parts for the older airplanes were unfortunately discarded. The TeamKitfox web community *(www.TeamKitfox.com)* is an excellent forum for Kitfox builders, owners and pilots.

In Summation

Whether you're interested in exploring backcountry airstrips at 120 mph or indulging in low-and-slow cruising during the smooth-air hours of the day, you'll find the Kitfox to be perfectly suited to your mission. Of all the Experimental kit airplanes that have come and gone through the years, it remains one of the most attractive options. The problem will be finding an owner willing to part with their pride and joy. Fortunately, you can solve that by simply ordering a Series 7 kit and setting to work building your own. ✈

Among the many different engines available for the S7 Super Sport is the 110-hp Rotec R-2800.

Experimental Audio Panels: Sophisticated, Integrated

PS Engineering and Garmin have kit-focused audio systems for under $2000. They have generous feature sets and high-end audio quality.

BY LARRY ANGLISANO

Forget everything you know about audio panels from the Reagan era. These days, the audio system is a major hub in a modern avionics suite that's used for a lot more than switching com radios. If you haven't shopped the audio market lately, you might be overwhelmed by the features that come standard. And even though you might not use the panel to its full potential, both PS Engineering and Garmin have brought the lowly audio selector to an impressive level that can reduce workload and better connect you with the systems on the aircraft and the passengers in the cabin.

For this article we took a fresh look at two full-up audio control panels aimed at the Experimental and LSA market: PS Engineering's PDA360EX/R and Garmin's GMA 245/245R. Yes, the "R" means both are available in remote form so you can control them on an EFIS. We'll skip TSO-certified panels for a simple reason: Why would you want to pay for the cost of certification? Both of these sub-$2000 full-featured panels have proven high-end performance and reliability when you install them properly.

How You Might Choose

Our advice for audio panel shopping is much like shopping for headsets because you want to sample the audio quality with your own ears and voice, plus you want to work with the user interface.

Garmin's GMA 245 gets high marks for its rugged user controls and good key lighting.

These panels do so many things that there will be a learning curve to both configure them after installation and make the features work on the fly. Sun 'n Fun, AirVenture and other gatherings are a good place to try them out. Bring your own headsets, if you can, even though the demo will likely be given with a Bose A20 at the kiosk.

On the other hand, your decision might already be made by your existing or planned avionics suite. There's software involved, and that means cross-brand compatibility issues. You won't be able to connect the PS Engineering PDA360EX-R unit to the Garmin G3X-series EFIS, and you won't be able to connect the Garmin GMA 245R to third-party EFISes. You could, of course, skip an audio panel altogether and install a stand-alone intercom but given the wiring effort to do that, we think an audio panel makes better sense for all but very basic panels. Plus, without an audio panel you might be short-changing other avionics in the panel that might output aural alerts from traffic, engine and landing gear systems; most common intercoms have a limited number of aux inputs for that purpose.

Even if your panel is as basic as it gets now, think about how it might look down the road as you add more stuff. Chances are, what you add will be able to interface with the audio panel, especially considering the prompts and approach guidance that stream from Garmin and Avidyne GPS navigators. Plus, popular apps like ForeFlight, FlyQ and Garmin Pilot have Bluetooth audio output that you can stream to the audio panel. Truth is, the audio control panel has become a major hub for lots of things on and off the instrument panel, and many modern interfaces are shortchanged without one or with an aging audio panel that's intended for basic switching functions, like it was before Bluetooth.

Garmin GMA 245

Priced at $1325, this panel has many features that trickle down from Garmin's flagship certified audio panels. We like that the Bluetooth GMA 245 is a slide-and-fly replacement for the older GMA 240. It also interfaces with Garmin's G3X Touch integrated avionics or can be operated as a stand-alone audio controller—or both.

The GMA 245's intercom circuitry has, as you'd expect, automatic squelch. Using digital signal processing, the panel automatically adapts to quiet or loud cabins by monitoring ambient noise levels and adjusts the microphone squelch accordingly. In our view, it was PS Engineering that set the standard years ago with its IntelliVox technology and Garmin has since joined the party with its smart squelch circuit. It works well, based on our use, and has what's called Master Avionics Squelch, or MAS. This prevents low-level noise from sneaking into the headsets. The feature can be fine-tuned after installation to best suit the cabin environment. There's also a configuration option for high-noise cockpits.

The panel can accommodate as many input sources you can throw at it, and that includes dual com radios, dual VHF nav radios and three aux receivers. Added up, that's a total of seven audio sources—likely more than many interfaces will need. A similarly generous IO applies for the intercom, which supports up to six seats (more than most Experimental have) and has three modes of intercom isolation. There's also a split-com mode that lets the pilot and copilot broadcast on independent frequencies. But to use this feature you'll need to provide good isolation of the com antennas—perhaps one installed on the top and the other on the bottom of the aircraft.

Following Garmin's tradition for decent ergos, the GMA 245 has a rugged feel and the bezel keys and controls are relatively intuitive, although

The Garmin G3X Touch gets on-screen audio control when paired with the GMA 245 or remote 245R.

the panel face is busy, with no fewer than 20 controls. As you would expect, pushbutton backlit keys control the audio source selection and when a key is selected, an annunciator on the key is illuminated. That annunciator brightness is adjusted automatically by ambient light level. Key backlighting brightness is adjusted by the radio dimming bus control. A dedicated AUX key turns on all three available auxiliary inputs. During com radio transmission, the active transceiver's mic key annunciator flashes approximately once per second—no excuse for a prolonged stuck mic with this attention-getting feature.

The panel's intercom includes two music inputs including the Bluetooth source and one wired telephone input for the pilot, copilot and passengers, and there's pilot and crew audio isolation from those sources via a dedicated isolation button. There are also dedicated volume controls for the pilot and copilot/passengers (the copilot's volume knob also adjusts the passengers'), plus a feature we like the best: a dedicated volume knob for the music. No need to grab for the smartphone to crank the tunes down or up. For keeping the phone juiced up, there's a Type A USB dedicated charging port on the panel's bezel, providing a maximum of 2.1 amps of charge current.

The audio control feature set on the G3X Touch (shown split screen) is intuitive, especially for music distribution and making phone calls.

There's also a dedicated wired or Bluetooth duplex telephone interface, useful for handling departure clearances at remote airfields. It's activated with the TEL key, which enables either Bluetooth telephone or rear connector-wired telephone connection to the intercom. Logically, when a Bluetooth telephone connection is active the rear telephone connection is disabled.

The dedicated Music key turns the music on or off for all positions on the intercom, while the down-arrow SEL key selects the music source (either Music 1, Music 2, or Bluetooth Music) for all positions. The pilot can choose not to hear music by either turning down the Pilot's music volume control or putting the intercom into Pilot Isolation mode. The copilot and passengers can kill the music by turning down the copilot/passenger music control. Want to customize the audio signature of the music? You can do it with a music effects feature that boosts the bass (medium or high bass), plus there's a music EQ features for selecting classical, pop or rock genres. As smooth jazz musicians, we're disappointed it left out a jazz setting, but so it goes.

Installation: Got Noise?

Over the years, in consulting with aircraft audio system pioneer Mark Scheuer at PS Engineering (and doing our own share of audio panel installations) one thing has always been clear: A bad install makes an exceptionally good audio panel nearly useless. Truth is that audio installs have gotten a bit easier and the effort to wire the thing up has been curtailed thanks to products like the Advanced Flight ACM-ECB wiring hub (and others like it), which has a dedicated connector port for plugging in the audio harness. But not all retrofits will have a hub, and you'll likely find yourself arms-deep in audio wiring. Do it right, or leave it to someone more experienced is the advice from the pros.

"The most important thing that's required to build a quality wiring harness is to be able to properly read the wiring prints," PS Engineering's Scheuer told us. He's right. There are critical footnotes that if not adhered to can cause all kinds of troubleshooting once you start using the system. Noise is perhaps the biggest nuisance because with any new high-end audio panel you'll expect flawless audio quality. These panels deliver, but they rely heavily on a skillful installation. We can't stress that enough. Where does the noise come from? Put on your engineering cap.

Garmin points out in its latest revision of its GMA 245/245R audio panel installation manual that because the audio panel is a point in the aircraft where signals from many pieces of equipment are brought together (it in itself is a hub), you really have to minimize the effects from coupled interference and ground loops. We've all heard the unwanted noise signatures. Ground loops are created when there is more than one path in which return currents can flow, or when signal returns share the same path as large currents from other equipment. These large currents create differences in ground potential between other systems operating in the aircraft, which can potentially produce an additive effect at an audio panel's input—and there's lots of sneak paths.

Use caution when routing the harnesses under the panel and through the cabin. Coupled interference can sneak into the audio system harness when they are routed near large AC electrical fields, AC voltage sources and pulse equipment (strobe lights, spark plugs,

The Garmin GMA 245 can slide into an older GMA 240 installation, both physically and electrically.

3D Audio

This is a feature that has been standard on Garmin's high-end panels for a while and it's included on the GMA 245, too. The idea is that 3D Audio might be useful when multiple audio sources are present—as in listening to both com radios at the same time. Maybe you're listening to ATIS or the field's Unicom while working a Center frequency and want better separation of the signals. By using different responses in each ear, 3D audio processing creates the illusion that each audio source is coming from a unique location or seat position in the cabin when it comes to intercom chatter. But you'll need to plan the interface early by installing stereo audio jacks, since the feature uses a different signal for the left and right channel. Use mono headsets (or mono headphone jacks) and you'll still hear all of the audio sources, but there will be no separation. These days we suggest all audio installs have stereo jacks, especially since many entry-level headsets are stereo (or have stereo/mono selector switches).

Garmin engineered the 3D feature well. Since you won't always listen to two radios at once, with a single com selected and 3D Audio enabled, you hear the audio source at the 12 o'clock position as you'd expect. But switch on the second com and you hear COM1 at 11 o'clock and COM2 at the 1 o'clock position. The 3D audio feature doesn't stop at the radios. The cabin intercom positions are processed to sound like their relative seat location. By default, the GMA 245 assumes the pilot sits in the left seat, but you can configure the system for your particular install. Last, you can turn the feature on or off directly from the panel by pressing and holding the Pilot key on the bezel and an aural prompt tells you the mode is active. We suspect some users will do just that; others will leave it on all the time.

Say Again?

Standard on the GMA 245 is a built-in digital clearance recorder that records up to 60 seconds of the selected com radio signal. Recorded audio is stored in separate memory blocks and once 60 seconds of recording time has been reached, the recorder begins recording over the stored memory blocks, starting from the oldest block.

Pressing the PLAY key once plays the latest recorded memory block.

If a com signal is detected during play of a recorded memory block, play is halted. Pressing the PLAY key while audio is playing begins playing the previously recorded memory block. Each subsequent press of the PLAY key selects the previously recorded memory block. You can stop the playback at any time by pressing the COM 1 MIC or COM 2 MIC bezel buttons.

magnetos and even co-located displays). Interference can also sneak into the audio wiring by magnetic induction when they are routed near large AC current-carrying conductors or switched DC equipment. Here we're talking heaters, solenoids, fan motors and even autopilot servos.

And since these panels have Bluetooth transceivers, you want to mount the remote versions, so you get the best wireless performance. Garmin and PS Engineering want the unit inside the cockpit where it will have an unobstructed view of the devices it connects to. That includes making sure the signal isn't shielded by the metal instrument panel structure. For best performance, Garmin prescribes mounting the GMA 245R with the front of the unit facing the cockpit and centered laterally between the two aircraft sides. For example, mounting the GMA 245R at the bottom of a center radio stack facing into the cockpit (aft) typically works well, though mounting it just below the instrument panel would likely produce better results. Don't put the unit in a metal enclosure or under a floor panel.

Last, use the right wiring. We've had our hands and ears in enough installs to know that unshielded wiring doesn't work well. Invest in quality three-conductor shielded wiring. But perhaps the most common audio flaws exist right where you'd least expect and that's at the audio jacks. Lack of shielding there can induce plenty of RFI noise into an otherwise sound audio system install. Test it on the bench first so you'll have a reference when connecting it up in the airplane.

—L.A.

The LCD bezel display on the PDA360EX has a shallow and intuitive menu structure for configuring audio on the fly, and it excels with dual-source Bluetooth.

PS Engineering PDA360EX

The $1396 (down from $1995 to be more competitive) PDA360EX trickles down from the company's flagship PMA450B, which is equipped with PS Engineering's IntelliAudio technology. Measuring 1.30 by 6.25 by 7.15 inches and weighing 1.5 pounds, the PDA360EX is plug-and-play with Garmin's GMA 240 LSA/Experimental audio panel. Other than price, it's worth noting that the PDA360EX differs slightly from the PMA450 in that it has a four-seat intercom (instead of six in the PMA450), it doesn't have marker beacon functions, it can't support a cabin speaker and it has no public addressing capability. But it does have advanced audio processing through IntelliAudio.

Originally licensed from the U.S. Air Force, IntelliAudio helps present the audio sources in a way that's more intuitive to process, or at least in a way that mimics how the human ear hears and registers sound. Air Force pilots know this technology as Multi-talker. This concept is similar to what Garmin does with its 3D Audio function. But PS Engineering takes the interface a few levels higher, making good use of on-screen graphics so the user can tweak the spatial positions of the audio.

For example, the user can place the signal sources in nine unique positions using a simple on-screen graphic. The intent of IntelliAudio, like Garmin's 3D Audio feature, is to make it easier for the pilot to concentrate on the radio of choice while ignoring the radio of lesser importance at the time. For example, the pilot can choose to pay attention to ATC while ignoring an ATIS broadcast, depending upon what is pertinent at the moment. IntelliAudio only works for com radio signals and not the intercom audio from each seat, which we think simplifies the user experience.

Even better is that PS Engineering attempts to simplify the user interface where it really counts and that's with an LCD bezel display window, while

EFIS Interfaces

With all the data displayed on the typical big-screen EFIS, it's logical to display the audio controller on the screen, too. You can do just that with the remote PDA360EX-R and GMA 245R. In the Garmin G3X Touch interface, the remote audio system is wired in over the CAN bus, and it won't work with any other EFIS but Garmin. But the G3X Touch will work with the panel-mounted version of GMA 245, giving you both a dedicated controller on the panel, plus a pretty rich on-screen interface. It also has Bluetooth, so you won't lose any functionality over the panel-mounted version. Still, the PDA360EX-R has a more open interface to play across brands, and PS Engineering told us it's been a brisk seller because of it.

We asked Rob Hickman at Advanced Flight Systems about audio panel interfaces with modern panels. He should know because his company kicks out plenty of custom panels through the Advanced-Panel avionics panel building services. Read all about it in the EFIS buyer's guide in the April 2020 issue of KITPLANES®. Hickman told us that almost all of the AdvancedPanel builds that include dual com radios use the PS Engineering PDA360EX panel. Moreover, almost every panel with the Advanced Flight AF-5000 series EFIS use the PDA360EX-R. It's connected to the suite via an RS-232 serial interface. The company's ACM-ECB electronic wiring hub has a dedicated port for the remote PDA360EX-R that automatically routes the RS-232 audio data to the EFIS. This essentially makes for a plug-and-play original install and easy future retrofit.

Since the AdvancedPanel construction projects also include Dynon avionics (including the HDX), Hickman says that most of these builds include the panel-mounted PDA360EX. But that could change, or at least morph into a deeper interface. Dynon has been working on the software for the HDX so that it will support the remote version of PS Engineering's panel and is hopeful the interface will be ready this summer as part of the SkyView HDX version 16 release. We'll keep tabs on that.

Other EFIS makers, including MGL Avionics, offer VHF radios that include at least some intercom capability. The MGL V16 com radio, for example has a two-place intercom with a wide-range VOX system and multiple headsets can piggyback to the passenger channel. There's even a readback recorder function. Audio control is accommodated on the Razor control head, a 3.2-inch touchscreen that communicates with the radio over a CAN bus. The GRT Avionics HXr EFIS models interface with the PDA360EX via RS-232.

BendixKing repurposes the PS Engineering panel as part of its xVue Touch Experimental EFIS, though we don't see why the panel-mounted GMA 245 won't work either, if that's your preference.

The takeaway is that when selecting the EFIS for your project, look hard at the potential audio interface. In our view, a reliable and full-functioned audio interface (with generous growth potential) is a must have, and audio panel compatibility is almost as important as the EFIS itself. Don't overlook the audio interface during your planning stages.

—L.A.

Those are the PDA360EX's function soft keys. The bottom is the on-screen pictorial for spatially orienting the radio audio.

Backstop a quality install by testing the system on the bench first. It's easier to troubleshoot on the bench than in the airplane.

also retaining traditional push buttons and a rotary volume knob for radio switching and basic intercom settings. We find that the display is especially useful for configuring the IntelliAudio dimensional sound through the Head Related Transfer (HRT) function. This is essentially a graphical utility showing where the sound is positioned relative to your head. You can quickly turn the IntelliAudio off and listen to the audio in a traditional manner through the IntelliAudio soft key on the display. The setup is refreshingly intuitive, in our opinion, and edges the display-less Garmin interface.

Once in the IntelliAudio mode, repeated pressing of the COM 1 or

That's a Dynon SkyView HDX-based panel sporting a PS Engineering PDA360EX audio panel in the center. Dynon says it's working on an interface for on-screen audio controls.

COM 2 line select keys moves a corresponding half-circle cursor to the locations relative to the listener graphic that's on the display. Press DONE to exit and save the configuration, where it's recalled at every system power up. It's really pretty easy to work with.

The PDA360EX is equipped with an internal readback recorder, which captures up to 45 seconds of audio. Recording is automatic and both the pilot and copilot can hear the playback.

Entertainment Input to the Max

From its early PM1000 intercom, we think PS Engineering has always taken entertainment and telephone input functionality to a higher level—and the PDA360EX is no exception with its integrated Bluetooth transceiver. In addition to music input, the feature set includes an on-screen Bluetooth telephone control, plus a bezel-mounted USB port, which can also be used for charging. It provides 1.5 amps, which can effectively charge most smartphones and tablets. When the phone rings, an incoming call menu opens, showing caller ID. Simply answer the call by pressing the top line select soft key on the display. The Bluetooth connectivity is quick and reliable, plus you'll know when it's connected because the display shows the battery level of the phone—a useful utility, we think.

No PS Engineering user can complain about not having choices for distributing the music and how it behaves with radio chatter. On the PDA360EX the music input function has three modes. In the All mode, music will mute with either intercom or when there is radio activity. In Karaoke mode, the music only mutes during outgoing radio transmissions, and in Radio mode it will mute whenever the com radio breaks squelch. A dedicated bezel-mounted music On/Off button is handy for quickly stifling the music. We like that you can listen to two Bluetooth sources at once because you might want to have both your navigation app and tunes streaming at the same time, and the PDA360EX lets you do it.

Worth mentioning is that PS Engineering has discontinued the PMA5000EX audio panel. There's still factory support,

Experimental Audio Panels

	Garmin GMA 245	PS Engineering PDA360EX
MSRP/MAP	$1325	$1345
Intercom Channels	6	4
Transmitter Capacity	2	2
Split Com	Y	Y
Receiver/Input Capacity	5	3
Digital Clearance Recorder	60 seconds	45 seconds
Alert Channels	4	4
Telephone Inputs	1	1
Bluetooth	1 channel	2 channel
Music Channels	2	2
USB Charge Port	1	1
Speaker Output	1	None
Slide-In Replacement For	GMA 240	GMA 240, PMA5000EX
Voltage Required	14-28 VDC	14-28 VDC
Dimensions (H x W x D), in.	1.3 x 6.3 x 8.1	1.3 x 6.3 x 7.2
Weight, lb.	1.8	1.8

of course, but you can't buy a new one. Also worth mentioning is Trig Avionics' TMA-series audio panel also priced sub-$2000. It's a TSO-certified device—which is why we didn't cover it here—but we'll include it in a report on Trig's full-stack upgrade in a future issue.

Conclusion

We think most buyers will be pleased with the performance of the Garmin or PS Engineering panel. When installed right (and when using quality headsets) they'll offer the best audio quality you can ask for in a small cabin. As for features, both companies knock it out of the park, especially when it comes to Bluetooth connectivity and the availability of unswitched inputs. We think the GMA 245's interface with the G3X Touch is smart and easy to use and installing the GMA 245/245R in these interfaces is a no-brainer. Install a G3X Touch and you'll also be installing a GMA 245/245R. Unfortunately, during stand-alone upgrades, we sense that many shops don't even recommend the PS Engineering product enough simply because they're used to selling a lot of Garmin. That's unfortunate.

For users who struggle with advanced feature sets, we give the PDA360EX the advantage because of its soft key-driven bezel display, which makes custom configuration on the fly easy. As we said, try them both and buy for your preference of the user interface.

The Advanced Flight displays have on-screen compatibility with the PS Engineering PDA360EX/R panels. Garmin's won't play.

Where Have All the Homebuilts Gone?

Thousands of E/A-B aircraft have been removed from the rolls, but most of them haven't existed for decades.

BY RON WANTTAJA

Most of you probably remember the heady days of the early 2000s, when every year saw the FAA's listing of the total number of homebuilt aircraft rise by a thousand airplanes or more. Every year, excited articles were triggered when the Experimental/Amateur-Built (E/A-B) fleet size expanded. "We've hit 30,000 E/A-B! 32,000! 33,000!"

Haven't seen such claims lately, have you?

And when today's numbers are published, they're hard to believe. If you've noticed any announcements at all, you're probably saying things like, "27,000 E/A-B Aircraft? Where did they all go?"

So, where *did* they all go?

Well, most of the missing homebuilts didn't exist at all—or, at least, hadn't existed for a few decades.

Let's take a look at what happened.

The FAA Registry

The FAA maintains a database of registered aircraft. It's actually several cross-referenced tables that, when combined, can provide a detailed description of a given N-numbered aircraft. Dozens of parameters are available, including make/model, serial number, year of manufacture, owner's name and address, installed engine, etc. When an application for an N-number is received, the plane is added to the registry. Special flags note whether this is just a reservation or is for an actual aircraft.

Now...the question is, when is an aircraft *removed* from the FAA registry?

That's where it gets fun. Prior to 2010, aircraft were only removed at the registered owner's request. Typically, the "owner" in many cases was an insurance company, canceling the registration after the aircraft was totaled. There were, no doubt, some conscientious owners who canceled the registration when they scrapped an old airplane.

But nothing forced them to. Other than getting periodic mail from the


Although several companies make Light Sport versions of their designs, only those licensed as Experimental/Amateur-Built are included in this report.

FAA, there wasn't any drawback being listed as the owner of a plane on the FAA registry. And because the owners didn't respond to any FAA queries, the FAA could never be sure whether the plane was still in existence or not. So they were kept on the record.

Security Concerns

After 9/11, the process for training pilots and registering aircraft came under a lot of scrutiny. The FAA was criticized for losing track of aircraft—for being unable to determine the actual owners of thousands of aircraft.

The requirement for triennial aircraft reregistration was born. Starting in January 2010, registered aircraft owners were required to renew their aircraft registration every three years. Reregistrations would have to be accompanied by a $5 fee; the owners couldn't just check off a box on a postcard and send it back. The actual program was phased in over three years, so that everyone's registration didn't expire at the same time.

Since 2010, more than 80,000 aircraft have had their registrations canceled. That's a 21% reduction in the overall U.S. aircraft fleet.

Homebuilt Consequences

As of January 1, 2010, when the program started, there were 31,914 E/A-B aircraft. As Figure 1 shows, the population coasted up to just over 33,000 by the end of 2011, but after that, the homebuilt population tanked. About one-quarter of the homebuilt fleet was removed from the registry between 2010 and 2013, dropping to less than 28,000 by the end of 2013.

This caused some angst in the industry. People were used to the fleet increasing by 1000 or so homebuilts every year. Yet the numbers dropped and *kept* dropping. By the end of 2018, there were less than 27,000 E/A-B aircraft.

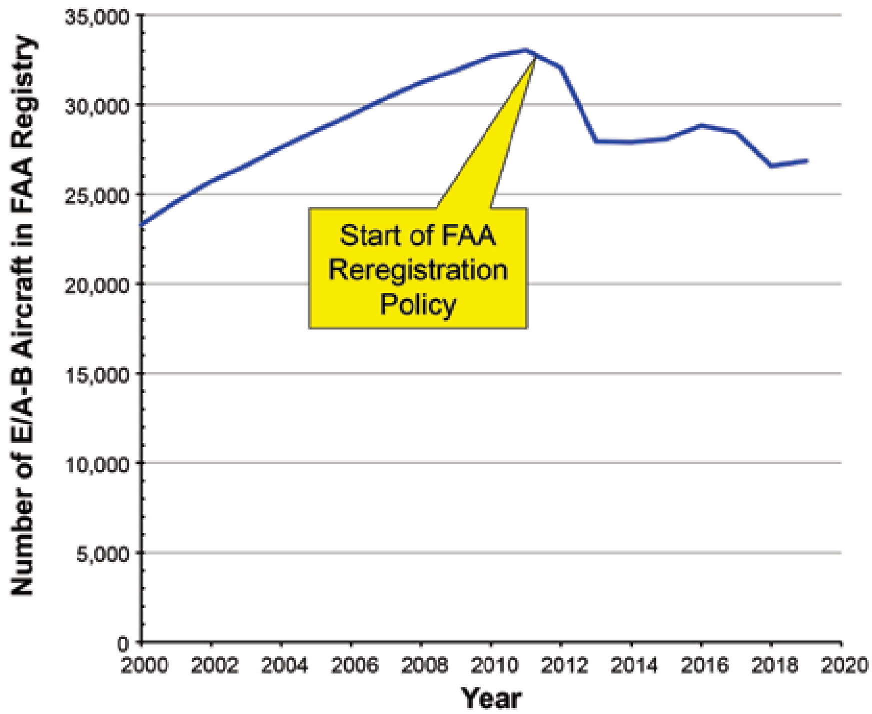


Figure 1: The total number of homebuilt aircraft was on a steady rise until the FAA instituted its triennial reregistration program.

In reality, the number of *active* homebuilt aircraft wasn't affected. There were just as many aircraft flying; in fact, there were still, on average, a thousand new homebuilts completed each year. As Figure 2 illustrates, the problem wasn't that homebuilt airplanes weren't being built; it was because of aircraft being removed from the registry via the reregistration process.

Hardest hit were older homebuilts, the ones from the '60s and '70s. Ninety percent of Bensen Gyrocopters were removed, as were about two-thirds of the Quickies. Half the Fly Babys disappeared, as did about half of the Sonerais, BD-4s and BD-5s. Oddly enough, the oldest homebuilt of all—the Pietenpol—wasn't badly affected. It lost less than 15% of the fleet. (You can find a table showing the effect of reregistrations for multiple homebuilt types at *www.kitplanes.com/fleet-size.*)

The reregistration process was removing the dead wood from the aircraft registry, just like it had been intended. However, there was an unexpected

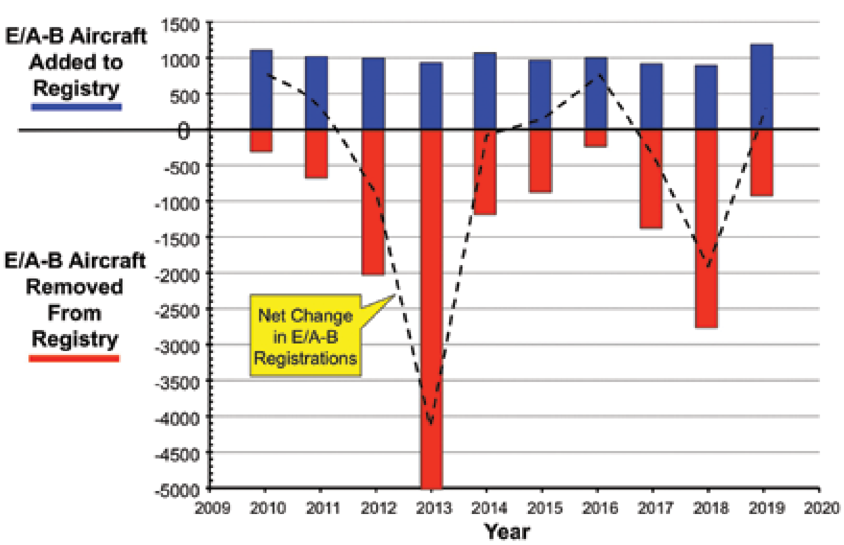


Figure 2: Since 2010, up to 5000 homebuilt aircraft have been removed from the FAA registry every year. Yet the production of new homebuilts is fairly constant.

Photos and illustrations: Ron Wanttaja

New Homebuilts Completed in 2019

Includes only companies with 10 or more completions

Type	Model	New E/A-B	Reregistered E/A-B	Total
AirCam	All E/A-B	11	2	13
CubCrafters	All E/A-B	61	1	62
	Carbon Cub EX-2/FX-2	10	1	11
	Carbon Cub EX-3/FX-3	51	0	51
Glasair	All E/A-B	20	4	24
Just Aircraft	All E/A-B	18	1	19
Kitfox	All E/A-B	29	14	43
Lancair	All E/A-B	12	11	23
	Lancair 4	6	4	10
RANS	All E/A-B	33	13	46
	RANS S-5	1	1	2
	RANS S-6	1	3	4
	RANS S-7	6	4	10
	RANS S-12	1	3	4
	RANS S-14	0	2	2
	RANS S-18	2	0	2
	RANS S-19	7	0	7
	RANS S-20	12	0	12
	RANS S-21	3	0	3
Rotorway	All E/A-B	10	3	13
Sonex	All E/A-B	25	7	32
	Onex	6	0	6
	Sonex	10	6	16
	Subsonex	2	0	2
	Waiex	6	1	7
	Xenos	1	0	1
Van's	All E/A-B	199	52	251
	RV-3	1	3	4
	RV-4	3	13	16
	RV-6/6A	18	21	39
	RV-7/7A	51	4	55
	RV-8/8A	44	5	49
	RV-9/9A	21	5	26
	RV-10	27	1	28
	RV-12	3	0	3
	RV-14/14A	31	0	31
Zenair	All E/A-B	60	7	67
	CH-601	6	2	8
	CH-650	6	0	6
	CH-701	14	4	18
	CH-750	31	0	31
	CH-801	3	0	3

New Builds: Newly registered E/A-B aircraft. Reregistered E/A-B: Previously deregistered aircraft restored to registry

Over 20% of new homebuilts in 2019 were RVs.

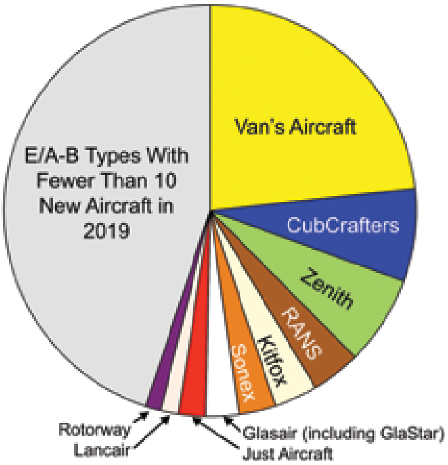
complication. The FAA was tracking homebuilt safety based on the number of accidents vs. the fleet size. With the same number of active aircraft, the number of accidents didn't change much. But with a huge drop in fleet size, the accident rate took a big jump!

Again, there was nothing actually *wrong*. It was just a byproduct of the dead wood being removed from the registry. But it certainly looked bad.

The issue was addressed at the annual EAA/FAA Recreational Aviation Safety Summit in February 2015. The FAA and EAA now emphasize tracking homebuilt safety by the number of accidents, rather than as a percentage of the fleet.

An Actual Drop

Buried in the chaff from the reregistration effort was the fact that homebuilt completions *were* actually slowing. About



A wide variety of homebuilt aircraft were completed in 2019. Relatively few companies saw 10 or more new aircraft.

While most older homebuilt designs were strongly affected by the FAA reregistration effort, the Pietenpol (left) saw a relatively low drop in fleet size. While only two new Glasairs (right) were added to the FAA registry in 2019, nine examples that had previously been removed were returned. *(Photo: Mark Owen)*

1100 new homebuilts were added to the roster in 2010, but by 2018, this had dropped to just 780.

What happened? We can't know for sure, but the primary culprit was probably the 2008 recession. It most likely triggered a steep drop in aircraft kit sales. Aircraft completions follow the sale of the kits by a number of years. Discretionary purchases like homebuilt aircraft kits probably took a while to resume, thus the kits purchased in 2011–2017 are just coming to completion.

More Homebuilts in 2019

Happily, we're seeing signs of recovery. Last year, 1179 new E/A-B registrations were added to the roster, the most in a single year since 2001. Three hundred thirty-five were previously deregistered aircraft that had been restored to the registry. But to the FAA, they count as new aircraft—so we'll count them, too.

If we ignore the "restored" homebuilts, 844 actual new homebuilts were completed. What types were they?

As one would expect, Van's Aircraft led the way: 199 of the new aircraft were RVs. The RV-7 took the lead, with 51 examples. Second place was a surprise—in more ways than one.

CubCrafters was number 2, with 61 new Carbon Cub airplanes of all models. What's more, the larger airplanes in the stable, the 2000-pound gross weight versions of the Carbon Cub, saw 51 new aircraft added to the registry in 2019.

That's the same as the RV-7. Van's and CubCrafters tied for the most-produced homebuilt airplane in 2019*.

Of course, Van's wide offerings dilute the sales of specific models. If the company hadn't offered the RV-8 and the RV-14, more customers probably would have opted for an RV-7, and the comparison wouldn't have been close. Still, it's interesting when you consider that the Carbon Cub kit costs about twice that of a quickbuild RV-7.

In close third place with 60 new aircraft was Zenith. Over half (31) were CH 750s and 14 were CH 701s.

Prognostication

What does the future hold? You're asking the wrong guy. Last year, I predicted that a lot more homebuilts would be deregistered in 2019 than actually were.

But things are certainly looking up. The net increase in homebuilts (new planes minus deregistered ones) was the second best in the last 10 years. The cyclical nature of the FAA's reregistration process should result in fewer removed from the roster in 2020, and there are probably plenty of kits bought during the recovery from the 2008 recession that will be finishing up.

To steal a line from Jim Weir—"Stay tuned!"

**The Carbon Cub EX-3 and FX-3 were counted together because the major difference between them is whether builder assist was used. Both models are licensed as Experimental/Amateur-Built. Similarly, the RV-7 and RV-7A (taildragger and nosewheel versions) were combined for the comparison.*

CubCrafters' EX-3 tied Van's RV-7 for number of new E/A-B aircraft registered in 2019. *(Photo: CubCrafters)*

Crimping Style

Repairing the cable on a Bose headset.

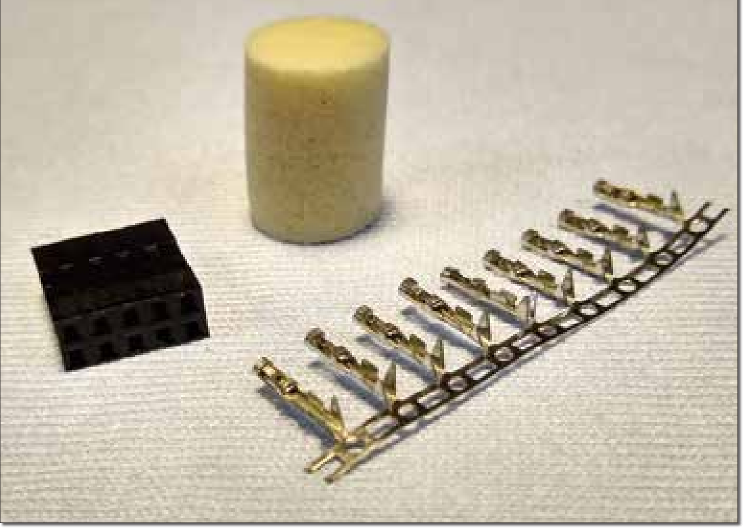
BY DAVE FORSTER

"Gulf Coast Regional Airport, Experimen—N90—Q, currently—ile—orth, inbound for—"

Drat! The headset is intermittent again!

The insulation on the cable from the ear cup to the battery holder had become frayed with age and use, exposing the tiny wires to strain every time the headset moved, causing them to break. Each time they broke, they were carefully soldered together, sometimes with a short patch wire, but this only concentrated the strain at the end of the new repair, and after three failures in the last 10 flights, it was time to look for a better solution. Unfortunately, Bose no longer repairs Aviation X headsets. There had to be a better way than spending 1 AMU (Aviation Monetary Unit) on a new headset when the old one was otherwise perfectly serviceable!

Good practice in aircraft wiring means restricting connections to only the two ends of each wire and avoiding splices or



2.54mm connector with earplug for scale (left). These are small connectors! SN-01BM crimper (right), used for the 2.54mm connector. Wires are inserted from this side of the tool.

other unnecessary connections in the middle. I was violating that good practice every time I soldered the wires and paying for it with an unreliable headset.

Pins and Barrels

The Bose headset uses a fixed connector in the ear cup, with pins sticking out to interface with the microphone assembly. This carries all the audio and noise-cancelling connections into the ear cups. Inside the microphone assembly are two connectors: one that is held in a molded bracket so it interfaces with the ear cup pins and another that connects to the microphone itself. Neither connector looks like the typical Molex or D-sub connectors used in the rest of the airframe, but careful measurement, online digging, and trial and error revealed that both connectors are in fact commonly used in personal computers and readily available through electronics suppliers. As the frayed portion of the cable only extended for a few inches below the ear cup, the bad portion of cable could be cut out and new connectors installed.

The main ear cup connector is known as a Dupont 2.54 mm "two by five," meaning there are two rows of five conductors with 2.54 mm spacing between them. This is quite a small connector.

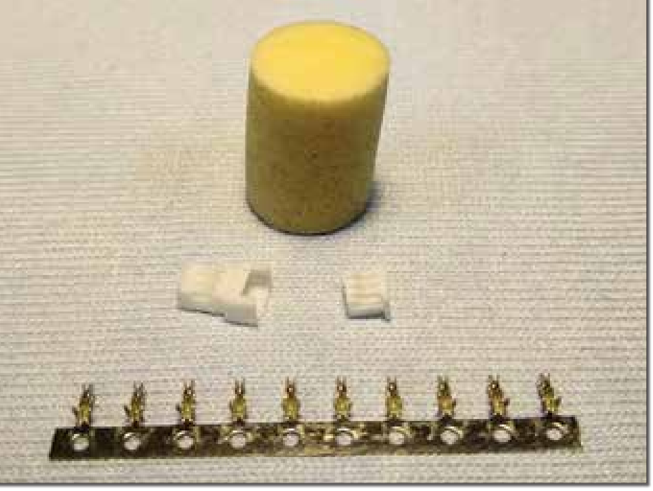
Connector descriptions typically show a measurement that is the distance between individual conductors within the connector. The actual conductors are a matching pair of pin and barrel, which are typically described by the size of wire they carry. There are different manufacturers of connectors, pins and barrels, and it is important to ensure that the style and size of pin and barrel match with the connectors they are intended to be used with.

Crimping Tools are normally sold with a reference to either AWG or mm2, which relates to the size of wire that will be crimped, as well as a reference to the model of connector system they are compatible with. It can get a bit confusing, but the important part when buying connectors and crimpers is to distinguish between the pitch (spacing) between the conductors in the connectors, and the size of the pins/barrels and the wire sizes they accommodate. For example, the SN-01BM crimper I used for the 2.54 mm connector is good for AWG 28–20, which translates to 0.08–0.5 mm2. Better crimping tools will have a ratcheting mechanism that will not release the pin/barrel until it has been fully crimped.

The microphone connector is even smaller. It is a 1.25 mm 3-pin Molex 51021/51047 PicoBlade. Similar to the above, the 1.25 mm refers to the pitch of the conductors. The 51021 end houses the female barrels that

Headset with microphone module removed.

Photos: Dave Forster



PicoBlade connector with earplug for scale (left). These guys are tiny! IWS-3220M crimper (right), used for the PicoBlade connectors.

connect to the end of the cable. The 51047 houses the pins and is on the microphone end of the connector. These are really small! When the ears of the pins/barrels are parallel to each other, they are only 0.04 inch (1 mm) apart. Working with them feels a bit like being an apprentice watchmaker. Unless you are blessed with the vision of a teenager, reading glasses and magnifiers are mandatory equipment.

For the PicoBlade connectors, I used an IWS-3220M crimper, which is good for AWG32-20 or 0.03-0.52 mm2. The jaws move a little differently from larger crimpers, but the principle is the same.

Stripping the wires requires a tool that can adjust down to very fine wires. I found a Stanley 84-213 stripper for 10–26 gauge wire works well, but it must first be adjusted to the correct size for the headset wires. Practice stripping the ends of the wires first, before cutting them to final length.

Assuming that the microphone (pin) end of the connector is in good condition, repairing the headset will require working only with the barrels—not the pins.

Each barrel has two sets of ears for crimping around the wire: one that closes around the insulated part of the wire and another that closes around the exposed wire end. Use some of the practice wires to set the stripping tool, and place a test wire end into a barrel to see how much exposed wire is necessary. With these small pins, only a small amount of exposed wire is needed—anything more would extend into and interfere with the area where the pins slide into the barrels.

There is one wire that runs between the connectors. Using a jeweler's screwdriver, it may be possible to lift the locking pins of the connector, extract the barrels from the old connectors and reuse the same wire and barrels in the new connectors. If not, be sure to save a length of wire from what will be cut off the end of the cable so a new wire with two new barrels can be constructed.

One Step at a Time

The actual process of repairing the headset is as follows:

1. Remove the two screws holding the microphone assembly to the ear cup using a Phillips (star) #0 screwdriver,

SN01-BM crimper with a barrel inserted in the jaws (left), ready to receive the wire end for crimping. On the right is an IWS-3220M crimper. Wire is inserted into the barrels from this side of the tool, with the barrel loosely held in the jaws until crimped.

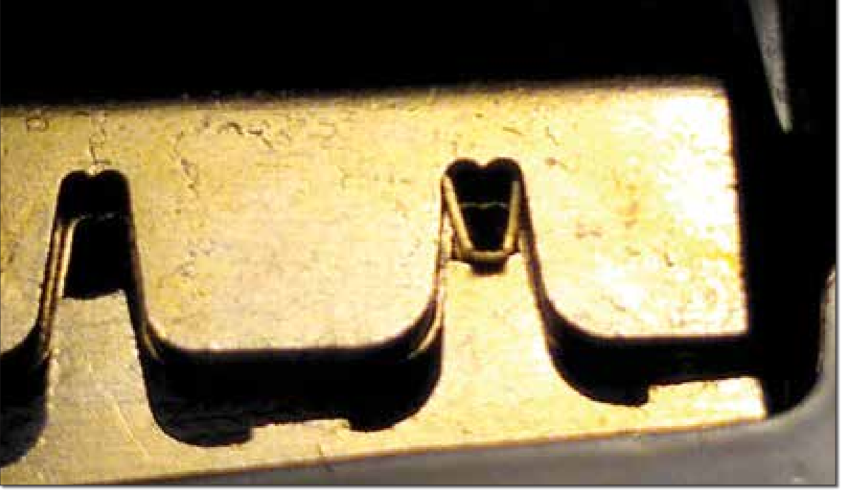
Tool Sources

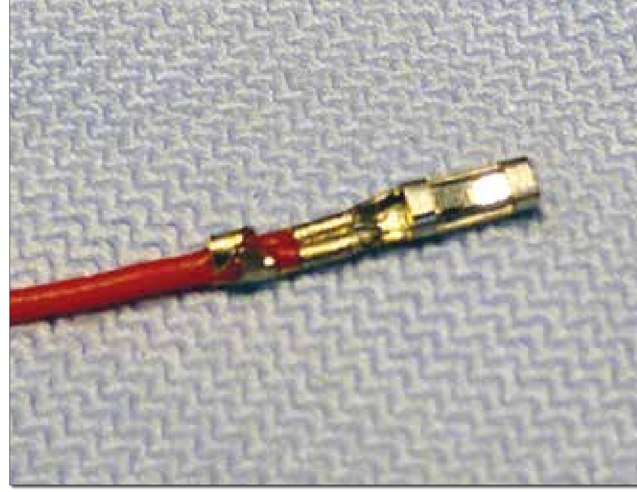
Everything for this project was acquired new on eBay, but the items are also carried by a variety of electronics parts suppliers (Digi-Key, Allied, etc.). There may be suitable alternatives to any of the following, but this is what I used:

- **Crimping Tool Crimper Plier with 610 pcs Dupont 2.54mm Connectors Assortment Kit: $20.88**
- **1.25 mm 51021 51047 PicoBlade 3-Way Male Female Connector Crimp Contact Pin Set of 10: $3.11**
- **Stanley 84-213 Wire Stripper/Cutter 10–26 Gauge: $3.50**
- **IWS-3220M Micro Connector Pin Crimping Tool 0.03–0.52 mm 32-20AWG Ratcheting Open: $34.98**

In addition, a magnifier head strap with lights from Harbor Freight for around $5 is a very helpful tool for seeing these small crimps.

—D.F.





Close-up of the barrel in the jaws of the crimper (left), ready for a new wire (inserted from this end). Close-up of a 2.54mm barrel crimped on the wire (right).

and pull the microphone assembly off the ear cup.

2. Remove the two screws holding the two halves of the microphone assembly together.
3. Disconnect the white 3-pin PicoBlade connector from the microphone.
4. Take some pictures and/or write down the colors of each wire and which position they go into on each connector. Depending on the manufacturer, the new connectors may or may not have their positions numbered, so be careful to take steps to ensure that the new connectors will be assembled with the correct wire colors in the appropriate positions.
5. Cut the old cable at a point where the degraded part can be discarded.
6. The old grommet where the cable enters the microphone assembly will be reused. Remove the grommet from the cut part of the cable, which will be discarded, and work the remaining good part of the cable back up through the grommet. This requires some patience. It may be easier to trim back the outer insulation of the wire first (see next step). Some dielectric grease may also be helpful to squeeze the grommet over the cable. The idea here is to get the grommet all the way over the black insulated cable; otherwise a new strain point will

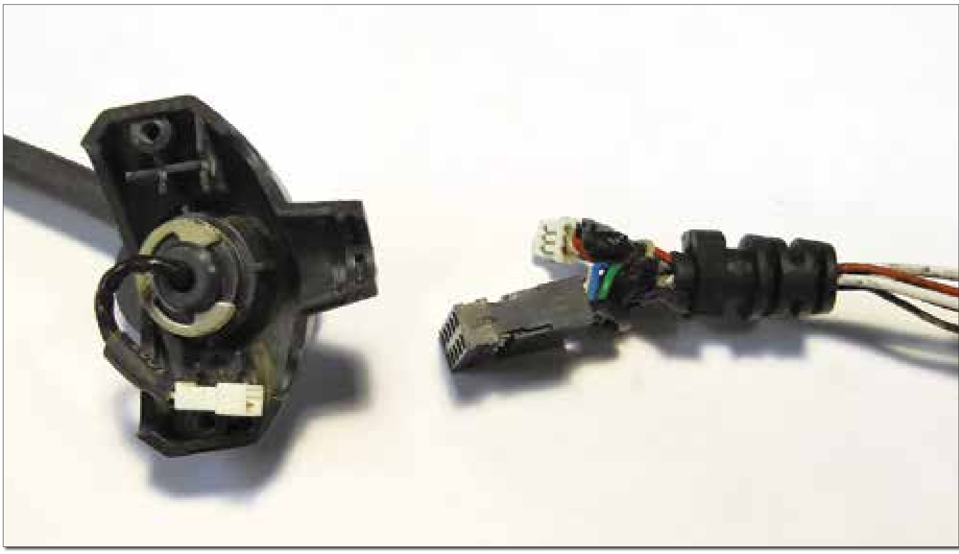
Microphone module as removed from the headset.

be created right where the cable goes into the grommet.

7. Carefully strip approximately 2 inches of the outer black insulation from the cable, exposing the wires inside.
8. Cut the wires about ½ inch from where they come out of the grommet and strip the ends.
9. Place the open end of a fresh barrel into the slot of the crimp die, with the insulation-crimping ears flush with the jaws on the side of the tool with lettering on it. Partially close the crimper to hold the die in position without actually crimping it yet.
10. Place the stripped wire end into the end of the barrel so that the insulated part of the wire will be covered by the first set of ears on the barrel.
11. Squeeze the crimper. Tug on the barrel to ensure it is securely crimped to the wire.
12. Repeat step 11 for the other wires. Make sure the correct size barrel is used for each color of wire. Five "large" barrels and three "small" ones will be needed (they're all very small!).

When placing the new barrels into the new connectors, it may be helpful to get them all started together, then press each one individually until it locks into place with a clicking sound. Tug on each wire to ensure it is locked in position. If it doesn't lock into place, the barrel may be upside down. Rotate it 180 degrees and try again. The hard part is now done! Plug in the new microphone connector, place the "two by five" in one side of the microphone shell and reassemble. Test in the airplane to ensure everything works and go fly!

If the old headset cable is not salvageable, a new multi-conductor cable could be acquired from an electronics supplier. However, be careful to ensure that the outside diameter of the wire is no greater than the old if you want to reuse the old grommets. One possible cable could be Digi-Key part no. T1351-1-ND (around $3). However, this is not a shielded cable and may or may not allow some electrical noise to intrude. Before proceeding with this, make sure the battery box end can be opened and confirm what kind of connectors are



Connectors disconnected from the microphone (left). Microphone module with halves split. The grommet around the bad part of the cable will be reused (right).

Repaired! The total cost, including some new tools and materials, was just over $60.

required. I could not get the screws to release on mine and gave up, as I was planning to leave this end of the cable alone, anyway.

The total cost of the repair was just over $60. This included acquiring a good stock of connectors, barrels, a new wire stripper and two new crimpers, all of which can be used on other projects ("It's an investment, dear!"). The end result is a slightly shorter cable, but hopefully the repair will significantly extend the life of the headset. ✢

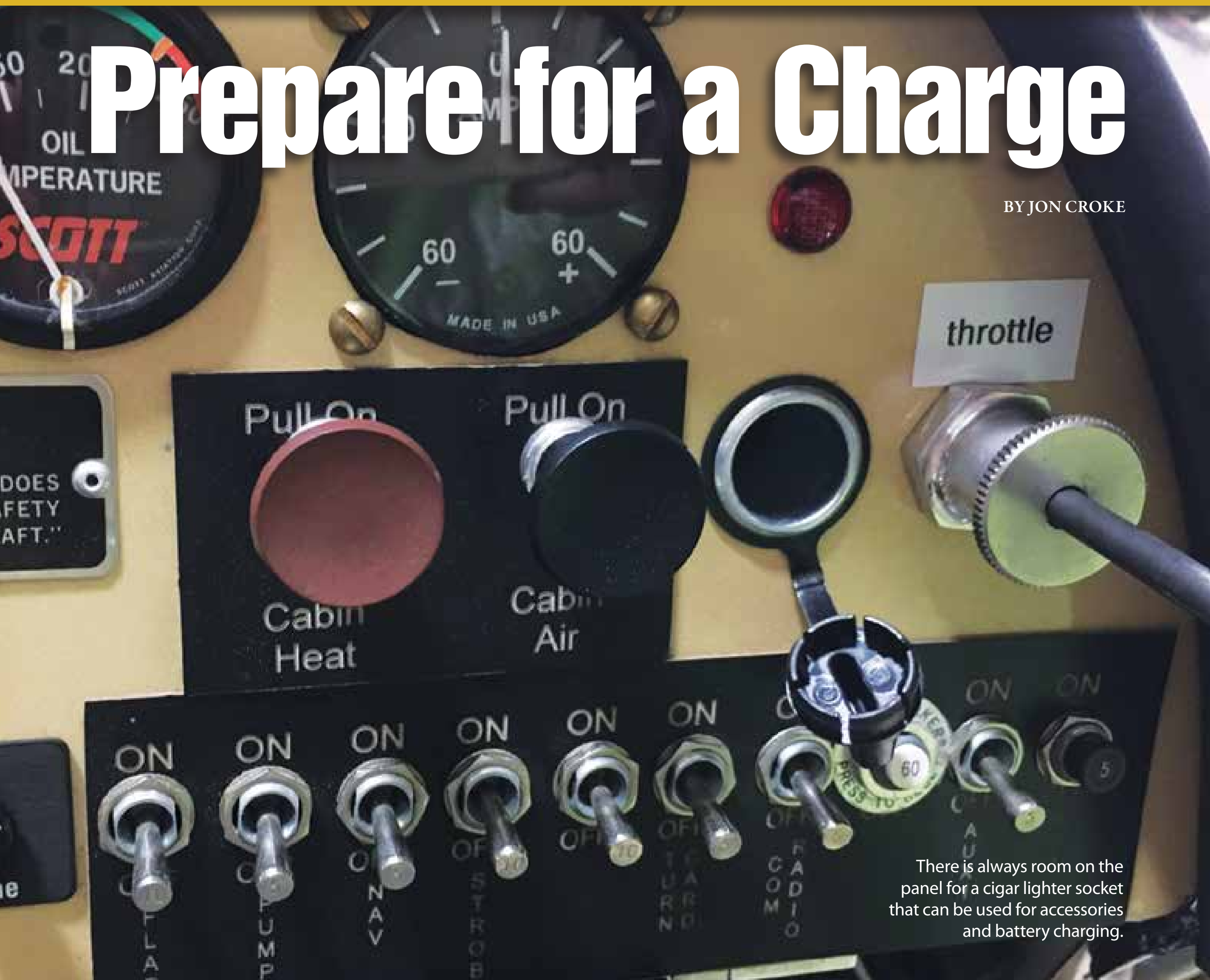
3D Printing a Replacement Bracket

If the wires are good, but the ear cup bracket has broken, see "3D Printing to the Rescue!" [October 2018] where we walk through the process of replacing a broken ear cup bracket for a Bose Aviation X headset, using inexpensive 3D printed parts.

—D.F.

Prepare for a Charge

BY JON CROKE



There is always room on the panel for a cigar lighter socket that can be used for accessories and battery charging.

The battery you install in your homebuilt kit will have nearly the same kind of life as the one in your automobile. It will perform flawlessly most of the time. However, once in a while it will show signs of problems, such as playing dead or just being too weak to start on a cold day.

If you fail to shut off an electrical accessory after flying, a charger may be needed to nurse the battery back to life. Flood an engine and the battery may not have enough juice to see you through to a start. An aircraft sitting dormant for the winter season may need a trickle charge to keep the battery alive, or a full recharge may be required when flying season returns. I have experienced all of these situations, and they almost always occur at some inconvenient time when I was hoping to just turn the key and fly.

Hooking jumper cables or charger clamps to the battery may involve removing the cowl and locating the battery terminals, which may not be so easy to access. Unlike an auto, your aircraft battery is probably not located right up front, with terminals exposed with a pop of the hood. We should plan our design to deal with the inevitable need to charge. And the best time to create an easy charging system for your battery is while you are wiring your aircraft.

One solution is to install an external charging receptacle made for this

A high-quality cigar lighter socket with terminals (left) allows you to wire suitably heavy cables directly back to the battery. An inline fuse is a must. Using a male cigar lighter plug with cable and ring terminals (right) allows a small charger to be connected for charging the aircraft battery.

purpose on the fuselage. These receptacles are not cheap and require a matching plug for them to work. Not everyone will have an appropriate plug, so it may be tough to get a charge while away from home base.

Fortunately, there is an alternative method to accomplish the same purpose: A quick and simple charging port using a high-quality cigar lighter socket will do the job. We need one with a high amperage rating and terminals for our own wire connections. Shop carefully online (Amazon or similar) to locate these. Then, create a wired connection from this socket directly back to the battery with a *fused* set of wires (12 gauge or larger) to handle about 20–30 amps. This means bypassing any battery contactor switches or solenoids when connecting the socket to the battery.

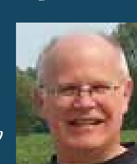
Adding a cigar lighter socket to your aircraft panel provides dual service. You gain a 12-volt universal port to power all sorts of accessories (think phone chargers with USB adapters, etc.), and you'll have a way to recharge your aircraft battery when it fails for any reason. While this is not the same as jump-starting your aircraft battery (jumping requires way too much amperage for this purpose), the 20- to 30-amp capacity of this socket allows most small automotive battery chargers to quickly bring your aircraft battery back to life. (Use an approved charger if you installed lithium batteries in your aircraft.)

The only part missing for completing this operation is to attach a *male* cigar lighter plug to your charger's clips (observing proper polarity, of course). The male plug with cord and ring terminals shown here was purchased from Amazon.

Plugging the male plug (with charger attached) into your panel's cigar socket provides a quick and easy way to bring your aircraft battery back to life without opening the cowl and searching for a good connection on the battery terminals. Any charger with less than 20–30 amps output can now be used to bring a weak battery back to life when overworked during flying season or to maintain the battery with a trickle charge during off seasons. By storing the male plug and cable with the aircraft, anyone with a small charger can help you restore your battery when away from home base. You will find that the simplicity of this setup is hard to beat when you need a quick charge to get back into the air. ✈

JON CROKE

As the founder of HomebuiltHELP.com, Jon Croke has produced instructional videos for Experimental aircraft builders for over 10 years. He has built (and helped others build) over a dozen kit aircraft of all makes and models. Jon is a private pilot and currently owns and flies a Zenith Cruzer.



Photos: Jon Croke

BUILDING TIME

The One True Airspeed

True airspeed is coy. It hides behind the more obvious speeds who tart themselves up with a meaningless facade. It's never overt. It makes you work for it. However, nothing worthwhile comes easy. I wonder how many homebuilders ever recognize it? How many ever come to know true airspeed?

Pilots like to brag about their conquests. The time they fought ice and turbulence over Kansas—a story told with animated hands and lips capped with a Clark Gable mustache. The time they laughed in danger's face as fuel ran low and they searched for their aircraft carrier in a squall. Their first solo after only one hour of instruction. Pilots have a gift for overstatement, and if they intercept a doubting eye at the telling of a tale they dismiss it with, "You weren't there," or "My buddy saw it, he can tell you." The buddy, of course, remains unnamed or her whereabouts are unknown.

When hard numbers are included in the tale, verification becomes much easier. Look no further than first-flight reports for questionable facts, usually in the form of reported airspeeds. Have so many pilots forgotten their ground school training regarding airspeeds? Never can a first flight reveal the one, true airspeed.

This photo captured an 11 mph disagreement between the two speeds that vie for a pilot's attention: ground speed (138 mph) and indicated airspeed (127 mph). Assuming no error in the instrumentation, a barometric pressure of 30.02 inches and a 68° F OAT, the true airspeed was 142 mph. *(Photo: Kerry Fores)*

The Airspeed Siblings

How do I put this delicately? Ground speed is not a real airspeed. Ground speed is the fickle stepsibling of airspeeds, often used to report aircraft performance but never reliable. It'll turn on you in a moment. One minute it has you seduced by a 200-mph ground speed and the next it's 120 mph. All you have to do to earn ground speed's cold shoulder is change heading or altitude. Or do nothing but fly a steady course into changing winds. Ground speed will wink at you from the GPS, but it's not to be trusted. It should never be used as a measure of your aircraft's performance.

Indicated airspeed responds to pressure. It is turned on by air molecules pressing against its diaphragm. On a cold day or when the pressure is high, it'll respond quickly. On a hot day or when the pressure is low, it is lazy. At a high angle of attack, it becomes unreliable, and if the pitot tube catches a bug, indicated airspeed may stay in bed as well. The higher you fly, the more lethargic indicated airspeed becomes. An airspeed indicator on a Space Shuttle would chill at "0" while it orbited the earth at 17,500 mph. You could say it felt no pressure to perform.

Calibrated airspeed is accommodating but not easy. Like its close sibling true airspeed, calibrated airspeed is never overt, never obvious. When the physical bits of your airspeed system aren't perfect (and they aren't), calibrated airspeed compensates for it.

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.

Calibrated airspeed likes to double-date with ground speed until its relationship with indicated airspeed is sorted. That sounds like work, I know, and that is why many pilots settle for indicated airspeed and ground speed. It takes work and time to get to know calibrated airspeed but know it you must if you want to experience true airspeed. The Phase I flight test period should be used to court calibrated airspeed.

True airspeed. There it is, hiding behind changing atmospheric conditions. Hiding behind pitot-static installation errors. Hiding behind design and manufacturing errors in the airspeed indicator. It is hard to get to know yet it is the only airspeed by which we can compare one airplane's performance to another. The only airspeed by which we can determine if the speed modifications we made have worked. The only airspeed that should be used to report your stall speed, your top speed or any speed that measures aircraft performance. True airspeed shows us what real airspeed is, regardless of wind speed or direction, the temperature, the barometric pressure, the altitude or the accuracy of our measuring equipment. It is true airspeed we must seek, as hard as it may be to ignore the flirtatious winks of indicated airspeed and ground speed.

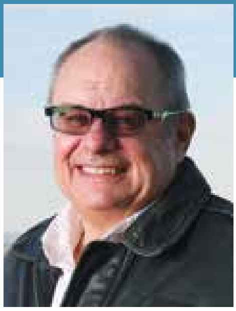
True Airspeed in the Digital Age

Many EFISes include a true airspeed (TAS) data field. The accuracy of the displayed speed can be akin to online dating. The photo is the person in question but the photo is 10 years old, before the person lost their hair and discovered the joys of a sedentary lifestyle. The TAS displayed on a digital gauge is only as accurate as the inputs. Those inputs come from the pitot-static system, an outside air temperature probe, an accurate altimeter setting and the integrity of the instrument itself. A small error in each input can produce a significant error in the displayed TAS. Like online dating, be hopeful the information is correct, but verify. However, this field can be a valuable tool, verified or not, when comparing changes to your aircraft's performance, such as while testing different propellers, engine tuning or drag reduction measures.

Protective Parents

First-flight claims like, "I built so well I stall 8 mph slower than the designer advertises," are void of meaning. The airspeed or GPS may have indicated 8 mph less than the design's specification but that is not the actual speed at which the wing stopped developing lift. We pilots like to think we are that good at flying. We like to think we were that good at building.

Physics don't bend to our will. An indicated airspeed is only a needle pointing to a silkscreened number. The accuracy of that indication must be confirmed through calibration flight tests. The calibrated airspeed is then converted to true airspeed by factoring in the altitude, temperature and barometric pressure. Math and science, you protective parents of the facts, why do you make it so hard to get to know the one true airspeed?



OUT OF THE BLUE

Go Around

I just returned from my annual airline recurrent AQP, or Advanced Qualification Program, training. (We sure are an industry and avocation of acronyms.) One theme of our training this year was an emphasis on go-arounds and missed approaches. Looking at data, the head sheds and head Feds apparently don't think we are doing either often enough. So we practice.

What's interesting about going around is that it is a fundamental flying maneuver across the spectrum of aviation—from the humblest two-seat trainers to the mightiest behemoths. Civilian or military, big or small, it doesn't matter what we're flying—we all learn about the go-around and practice them from our earliest training and throughout our entire occupations and avocations.

In its most basic form, the go-around is a tool in our pocket and, hopefully, an ingrained habit pattern in all of us. It should be used to eliminate the need to make tough decisions at critical times—such as on short final for landing. It's a reset, a do-over, an opportunity to reevaluate and potentially re-situate on a gentle, unpressured downwind. The go-around gives you time to better prepare for a more appropriate, more stabilized arrival. By the way, that arrival could be to the original airport runway or, depending upon conditions, maybe to a different runway or even a different airport.

Committing to the go-around in an airliner isn't a lot different than in smaller aircraft. Big-iron pilots trained for it even if we don't do it much.

What Went Wrong?

Often we find simply find ourselves high and/or fast on approach. From a Cessna 150 to an Airbus A380, sometimes the old gal just doesn't want to come down like we need her to. Little guys have the advantage of slip maneuvers that big iron drivers don't. (It's not that a Boeing *can't* slip; it's that neither the passengers nor the fanjet engines, which depend on unrestricted airflow, would be happy about the maneuver.) But while slipping is also an important option to learn and can "save" some approaches, it still doesn't negate the importance of recognizing when going around is the right thing to do. The same applies to limited use of speed brakes the big guys have. They're a great tool, that's true, but the time to correct and save a non-standard approach is early on the arrival, not on short final.

Sometimes we put ourselves into a situation where a go-around is needed, and it's our fault. We simply screwed up. It happens to the best of us. We started down late, misjudged the distance to the runway, whatever. We've all done it. Sometimes it's a controller's fault for putting us in a tight situation for their own needs, such as traffic. Sometimes controllers or "little guy" traffic get blamed in the subsequent P.A. to the passengers explaining why we're taking a low-level sightseeing tour of southwest Chicago—whether actually true or not.

Sometimes conditions change on board the aircraft, such as selecting flaps that subsequently don't operate correctly.

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.

Oftentimes, weather conditions change—a sudden shift in wind direction or speed can make a different runway the more prudent and safer choice.

When It Happens

I once had my landing clearance in a Boeing 737 canceled on short final at Burbank Airport's Runway 8 and told to go around and fly a visual approach to Runway 33—because police officers and bank robbers were in an intense gun battle right off the end of Runway 8. True story. One time I was lined up perfectly in the slot…short final for the dirt strip at Mulegé, Baja California, Mexico, when a soccer ball rolled out onto the runway followed by several local kids and a couple of dogs who obviously didn't hear or see me. It was the first time I ever went around in Spanish, but for full disclosure, I did it with a low approach so that the *chicos* would *darse cuenta* and clear the runway.

Sometimes our wheels have already touched the runway and we still need to go around. Little guys usually don't do landing performance calculations like big guys. But all calculations are worthless if you float down past the touchdown zone. The first third of the runway is a good gouge for everybody. Touching down beyond that point is adding significant risk and is a prime time to go around and try again.

Stuff Happens, Out of the Blue

Going around is a good thing to practice and should be part and parcel of all check rides and reviews. Know the procedures. One change between the maximum flap settings on Cessna 150s and their C152 replacements was the elimination of the very effective max flap setting, all because those big flaps could make the aircraft difficult to fly on a go-around if not retracted. Most aircraft approach speeds and climb-out speeds are very similar. Therefore, if properly trimmed, the airplane should fly out nicely with minimal trim changes after the advancement of power. Don't forget items like carb heat, prop controls, cowl flaps, etc., which should be routinely taken care of on every final approach in the possibility of a go-around/missed approach.

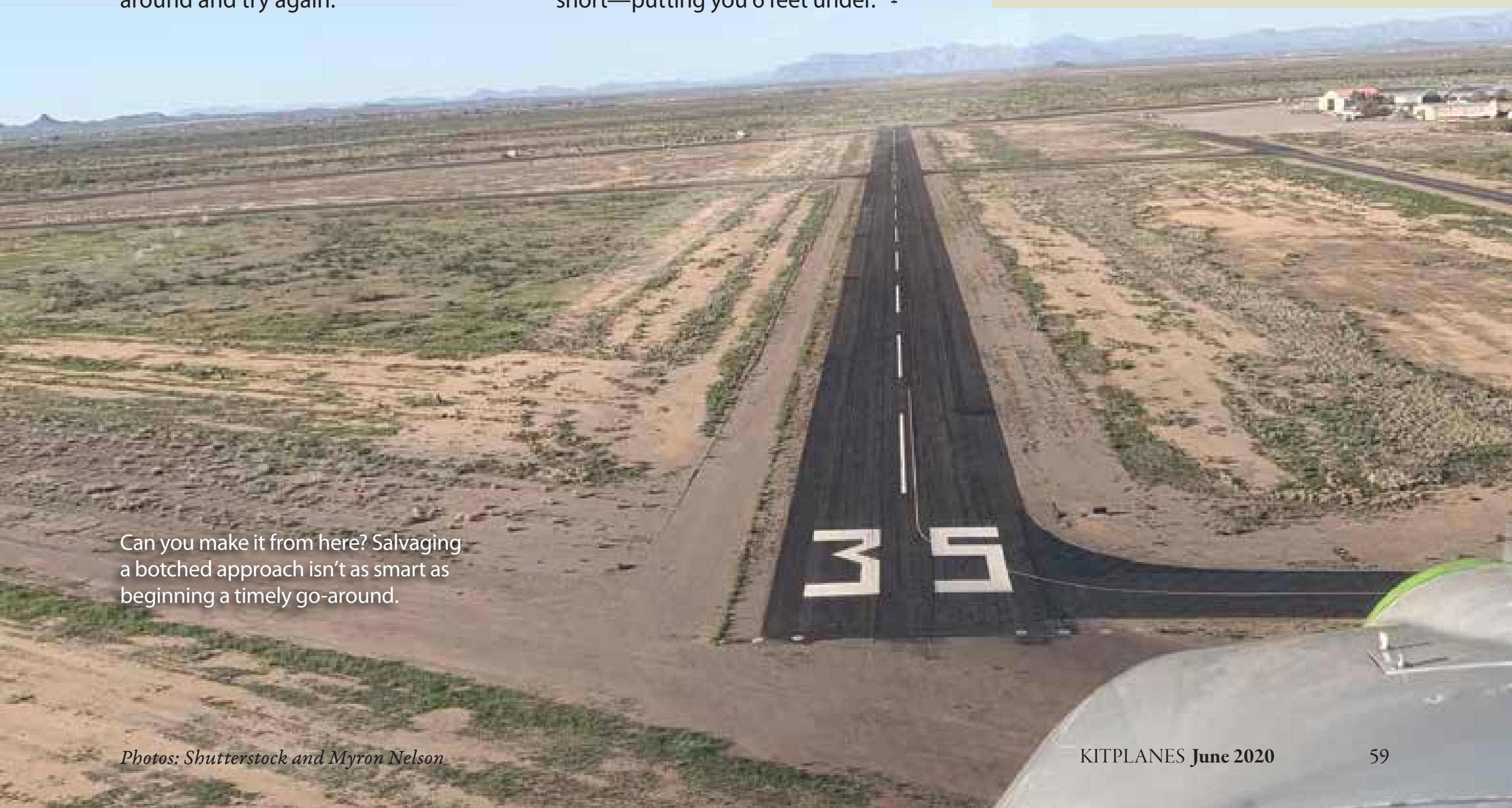
Sometimes pilot culture considers saving a botched approach as superior airmanship. It isn't. Sometimes pilots are hesitant to go around because it is viewed as admitting to a mistake. So what? It is much preferable to being in the chief pilot's office and everyone present has a chair except you. It's much better than seeing the shock of the premium spike on your next insurance renewal after a mishap. Of course, even those are preferable to being 6 feet over or 6 feet short—putting you 6 feet under. ✈

Many Go-Arounds Are the Same

The mechanics of a go-around procedure are pretty much the same in any aircraft thanks to the trimmed approach speed being similar, if not identical, to initial climb-out speed. The biggest differences are configuration, flaps, landing gear and automation. Boiled down to basics, in any aircraft that I can think of it is:

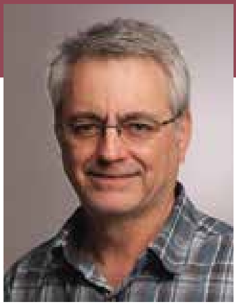
1. **In all cases, fly the airplane.**
2. **Advance power to a go-around setting.**
3. **Pitch up to initial climb angle. This should generally happen automatically due to the approach trim setting. If your airplane doesn't do this, you should know it from your testing and practice and fly accordingly. A pretty universal initial target is 10–15° pitch up.**
4. **Once a positive rate of climb is verified, reconfigure as required. Landing gear, flaps, cowl flaps, etc. Until the airplane is actually climbing, all of these can wait.**
5. **Climb to safe altitude (often but not always 1000 feet agl) for final configuration changes and initiation of Plan B.**
6. **Maintain situational awareness!**

—M.N.



Can you make it from here? Salvaging a botched approach isn't as smart as beginning a timely go-around.

Photos: Shutterstock and Myron Nelson



The Other P Factor

Late last year I flew from Southern California to Tucson and back in my Jabiru Light Sport. The flight was about 3½ hours each way, which is about an hour longer than I usually like to go without a rest stop. I figured I could make it, but I had a plan just in case I needed to relieve myself in flight. My solution was decidedly low tech: a 16-ounce sports bottle—the kind cyclists and runners use. Although I had never actually peed into one before, I figured it wouldn't be a problem. My thinking was, as long as I properly seat the lid and close the nipple, it won't leak.

Sure enough, after about two hours I had to go. I thought for a second, "Should I land, hold it, or…?"

Since I was prepared to go, why not?

The timing and the situation were ideal: there was no traffic on my ADS-B screen, no ATC chatter on flight following and I was cruising in smooth air.

As calmly and methodically as I could manage, I unzipped, wiggled my trousers down, went, sealed the lid, stored the now half-full bottle, wiggled my trousers back up and re-zipped. All in all, it went well. At no time did I ever think, "You're in trouble." I had to stretch a little to get the bottle angled right, but I didn't bump the controls or drift off course—at least not any appreciable amount.

After landing, I dumped the waste, thoroughly rinsed the go bottle to eliminate any lingering smell and stowed it for the return flight.

A couple days later, as I prepared to take off for home, I more or less expected the same scenario. I ate the same breakfast with coffee and stopped in to use the *very* nice restrooms at the Manara Regional Airport (KAVQ) pilot's lounge.

A couple hours later, as if right on schedule, I started to get that "I've gotta go…" feeling. No problem. Less than five minutes later I was back to normal.

Then, maybe 15 or 20 minutes after that, I got the urge to go again. What the heck? I had been sipping water, but no more than normal.

Regardless, I figured no problem, right?

Not exactly. The contents from the previous event complicated matters. Although less than half full, sloshing liquid doesn't give much leeway when you can't stand up straight. Believe me, at least *some* leeway is needed to maneuver into the position within the cramped confines of a Light Sport airplane.

But I managed.

Then…

Wouldn't you know, about 20 minutes after that, I had to go yet *again*. By now I was just outside of Palm Springs and only 40 minutes from home, so no way was I stopping just to pee.

Only two problems: the 16-ounce sports bottle was at least two-thirds full, *and* I was approaching the mouth of the San Gorgonio pass, which, if you know the area, is home to about 4000 wind turbines. In other words, turbulence could hit any second.

Rather than go into details, I'll conclude by saying that the 16-ounce sports bottle was not big enough, and I was especially thankful to have had a half-dozen micro-fiber towels on board.

Would I do it again? It depends. Most people I talked to (after the fact, of course) thought I was nuts. "I just stop every two to three hours, regardless," was the typical answer from both men and women. Virtually none of the casual fliers that I talked to had any interest in peeing while in flight.

But the fact remains, it is possible, and more than a few pilots do. You can even buy accessories designed for the task. Aircraft Spruce, Wicks and probably every other pilot shop in the country sells a plastic pee bottle called the Little John Portable Urinal.

The Little John is basically the same as peeing into a sports bottle, although it holds more than a typical sports bottle. Another option is a so-called external catheter style. I bought one on Amazon made by OOCOME.

Although I have not yet flown with either, what follows are comments based on ground testing. Your results may vary.

The Little John portable urinal (left) and with the Lady J attachment (right).

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 OOCOME portable urinal has an external catheter that drains into a plastic tank (left). The tank holds almost 68 ounces, more than twice as much as a Little John. The OOCOME portable urinal takes up a fair amount of space. While it fits with room to spare under the pilot's knees in a Jabiru (right), it may not fit so well in an aircraft with a more reclined seat position.

Little John ($11) and Lady J Adapter ($9)

The Little John Portable Urinal holds 32 ounces (950 ml) and has a handle. A handle may not seem like a big deal, but the first time I went into the sports bottle, the unexpected warming gave me the false sensation that I had missed. The spout is angled, which helps for in-flight use. The lid isn't tethered to the bottle, so you have to be sure to put it someplace where it won't get lost.

I asked a fellow Jabiru owner, Wanda Schuler of Red Bluff, California, to ground-test the $9 Lady John adapter for the Little John. The manufacturer says the Lady J "can be used sitting or even standing," but Wanda reported, "It was a bust for any possible use in the Jabiru. There just isn't enough room to get the angle right. I don't think I could do it as a passenger, let alone as the pilot."

Leak testing the OOCOME flexible hose.

OOCOME Portable Urinal for Men ($14.99)

Designed for hospital and invalid use, the OOCOME holds more than twice as much as the Little John and has the advantage of the external catheter with tethered lid and a hose so you can place it on the cabin floor and not have to worry about tipping or sloshing. My first test run proved the hose, at 42 inches, was too long for use in an airplane—unless you want to drill a hole in the floor and let it fly (so to speak). To drain into the tank the hose has to be more or less straight, with no loops or coils. Sitting in the pilot's seat, I had to hold the receiver up above my head to get the contents to drain into the bottle. The second try went much better after cutting the hose to about 18 inches. If I ever decide to use it in actual flying conditions, I'll add a bead of silicone sealer where the hose goes into the lid (the main complaint on Amazon is that it leaks there) and Velcro the bottle to the floor to prevent it from moving around. ✈

The Military and Lindbergh Options

There are a number of other options one might consider, including adult diapers. It all depends on your comfort level.

Wanda Schuler sent me a link to an interesting video called *Female Fighter Pilots: Urinary Devices Modernization (https://tinyurl.com/wrkqmpm)*. Without giving away too much of the plot, if, like me, you thought the military had decades ago solved the problem of peeing in flight, not so! Only in the last few years (and apparently in response to the previously dismal system) have they started using a so-called Aircrew Mission Extender Device (aka AMXDmax). I'm sure more than a few pilots are relieved to have a good system finally available.

Which brings us to what did Lindbergh do when he had to go during his 33½-hour solo flight across the Atlantic? It's 1927 and there are no sports bottles or Little Johns. One story purports that Lindbergh confided in King George of England that he went through a hole in the seat into a funnel that drained to the outside.

I checked with the Smithsonian and according to Dr. F. Robert van der Linden, curator of air transportation and special purpose aircraft at the Smithsonian Institution National Air and Space Museum, "There is no hole in the seat, and the seat is covered by a cushion."

So what did Lindbergh do? Given his fanatical objection to anything that added unnecessary weight, most likely, he simply went in his flight suit. But, as Dr. van der Linden pointed out, "Lindbergh does not mention how he dealt with this issue in any of his books, so we just don't know for sure."

—B.H.

Photos: Bob Hadley

Carburetor Maintenance

Because most amateur builders use Lycoming or similar engines equipped with Marvel-Schebler carburetors, we will focus on them for this article. Rotax owners must accept my apology for leaving them and their Bing carburetors for another day. They don't have a lot in common besides both being called a carburetor.

Marvel-Schebler carburetors have been delivering fuel to aircraft engines for a very long time. Although they're almost the only game in town today, the brand actually had some competition back in aviation's early years. They aren't fancy, but they get the job done. Little is asked of the owner in return for years of usually trouble-free service, but little is not the same as nothing. Let's look at some carburetor basics and what it takes to keep them happy.

The data plate on the side of the carburetor provides information you will need to order parts or a rebuild kit. You may also need this information to see if an AD or service bulletin applies to your carburetor. This one is a Model MA-4SPA, a model commonly found on Lycoming O-320 engines.

How They Work

The carburetor needs clean fuel in sufficient volume to meet the fuel flow requirements of the engine. Typically, this is about half a pound of fuel for every horsepower per hour. Thus, a 180-hp engine running at 75% power (120 hp) will need about 60 pounds (10 gallons) of fuel per hour if the engine does not require excess fuel for cooling. Some installations will tolerate running leaner in cruise. For takeoff, that number would increase to 15 gph, which means you need a safety margin of 25% to 50%, depending on the fuel system. Bottom line: The fuel system has to be capable of providing more volume than the carburetor requires at maximum power.

Fuel can be delivered by means of gravity flow from a high-wing design or via a low pressure (4–6 psi) mechanical pump. Typically, high-wing designs won't have an electric boost pump, though there's no reason why they couldn't, while low-wing installations are best served with a backup to the mechanical, engine-driven pump. The important thing is to be sure there is sufficient flow. Pressure is not much of a concern if the flow is there—for many Lycoming applications, the minimum pressure is just 0.5 psi. For a review of fuel system testing to ensure proper flow please see my article, "Firewall Forward: Fuel Systems," in the October 2012 issue of KITPLANES®.

Once fuel has entered the carburetor it goes to the float bowl waiting to be drawn into the engine. Floats attached to a needle valve let fuel in as it is needed and prevent it from flowing when it is not. Fuel is then drawn out of the float bowl by the low-pressure air in the carburetor venturi as it passes through. The flow of air is controlled by a butterfly valve in the carburetor that is connected to the airplane's throttle control. A separate circuit controls fuel flow during idle. A mixture control adjusts fuel flow manually to achieve the best fuel/air ratio for a given power setting and altitude. Simple, as it should be.

The pilot can control two things: the throttle opening and the fuel flow at

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.

This is the side of the carburetor that normally faces the firewall. Here you can clearly see the idle mixture screw that is marked "L" for lean and "R" for rich. It can be difficult to see these marks with the carburetor installed in the plane.

any given throttle opening (mixture). Two other things can be controlled with access to the engine compartment: idle mixture and idle speed.

Controls

The main concerns for the controls are free and correct movement and full travel from wide open to completely shut. It is vitally important that the mixture control arm on the carburetor rests against the stop in the shut-off position. Otherwise, the mixture control will not shut off the engine when pulled out. Similarly, the mixture control arm must open fully against the stop when the control is in the wide-open position. If it is not, the full-power mixture may be too lean.

The throttle must also have full travel to ensure that full power can be delivered when the throttle is wide open. When it is closed, if it does not rest against the idle adjustment screw you will not have control over the idle speed. This all seems pretty basic, but you would be surprised how often planes do not have complete travel of the mixture and throttle controls. I often see this when inspecting RV-8s. Any troubleshooting of potential

This is the side of the carburetor where the fuel goes in—usually the left or pilot side of the airplane. The carburetor fitting normally takes a ¼-NPT fitting but some carburetors need a Parker 6 CTX-S, which is a ¼-NPTF fitting. If you can't track down the Parker fitting, Marvel-Schebler will sell you a fitting for the carburetor that is threaded for ¼-NPT.

Photos: Dave Prizio. Drawing: Marvel-Schebler.

This is the throttle (right) side of the carburetor. The throttle is in the wide-open position with the arm against the stop. The idle adjustment screw can be clearly seen right below the arm. Note that adjustments to the idle mixture may require small adjustments to the idle speed.

carburetor problems should start with this basic evaluation of the control travel.

The idle mixture control is something an Experimental owner can easily adjust with access to the engine compartment. This adjustment controls the mixture when the engine is idling with the throttle closed or nearly closed. To check that the idle mixture is set correctly, watch for a slight rpm rise when you shut the engine off with the mixture control. You should see a rise of 25 to 50 rpm just before the engine shuts off. If the rise is less than that, the idle mixture is too lean. If it is more than that, it is too rich. Adjust the idle mixture by turning in or out on the idle mixture screw. In will make the mixture leaner and out will make it richer. Make small adjustments of about one-half turn or less at a time. See the photo above for the location of the idle mixture screw and note that the direction you need to turn the screw is marked on it.

The other adjustment you can make is to the idle rpm. With the mixture rich and a warm engine, idle should be at 650 to 750 rpm. My preference is toward the low end of that range, but it is crucial that the idle is high enough to be sure that the engine will not stop running with the throttle closed and carburetor heat applied. Needless to say, the throttle control arm must rest against the idle adjustment screw when the throttle is in the closed position. Otherwise you will not have control over idle rpm.

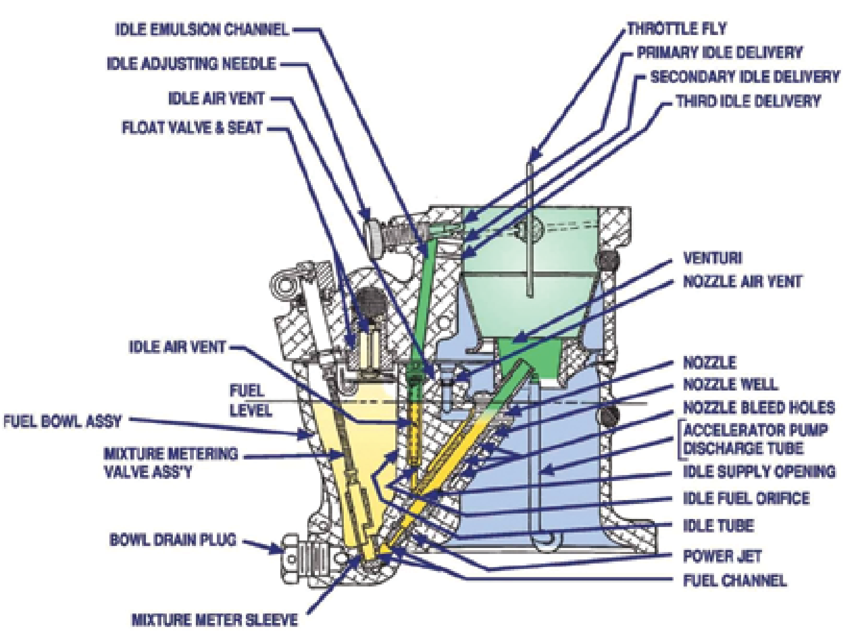
Routine Maintenance

Routine carburetor maintenance mostly does not actually involve the carburetor. It consists of keeping the air filter clean, the airbox in good shape (many are prone to cracking) and the fuel filter clean. If you do that regularly and keep your fuel clean and free of water, you have covered most of the maintenance needed. Whenever you have the cowl off, it's a good idea to check for any signs of fuel leakage. These need to be corrected immediately if found.

Also check the airbox for soundness and secure attachment to the carburetor. Over time it can crack or come loose and allow unfiltered air into the engine. The screws that attach the airbox to the carburetor should be safety wired to prevent the airbox from coming detached from the carburetor. By the way, Marvel-Schebler recommends that you use copper wire instead of stainless steel safety wire on the carburetor. That said, my Precision Airmotive (same as a Marvel-Schebler model) carburetor came from Lycoming with stainless steel safety wire. I'll leave the choice to you.

Heavy Maintenance

Over time, the parts inside the carburetor can wear out and the parts of some older models can fail internally. At that point, some heavy maintenance may be needed. I define heavy maintenance as any work that requires the carburetor to come apart. Many owners are not comfortable performing this kind of work. For them, an overhaul by the factory or a competent shop may be the best answer. An overhaul for a carburetor such as the one shown in this article, the Marvel-Schebler MA-4SPA, runs around $800. That may sound like a lot of money, but a new one runs



To understand the cutaway drawing better, the green is fuel/air mixture, the yellow is fuel and the blue is air.

about $2000. Marvel-Schebler recommends that its carburetors be overhauled at engine overhaul, typically every 2000 hours or 10 years.

With newer operating limitations for Experimental/Amateur-Built aircraft, you are obliged to adhere to this limit, though many currently flying homebuilts are not under this version of the ops limits. Still, it is no secret that there are many 30- and 40-year-old carburetors out there that have never been apart. That is a testimony to the durability of the carburetor, not the good judgement of the owner.

Any owner who wishes to tackle the overhaul or major repair process can purchase an overhaul kit from Marvel-Schebler. This is not brain surgery by any means, but if you are unfamiliar with this kind of work it would pay to get some assistance from someone who has done this before. After all, the carburetor is a pretty important part of your engine. Very complete kits are available in the $400-500 range and include just about every internal part that could wear out or fail, except for the floats. You can also buy individual parts from Marvel-Schebler through its website.

A key maintenance item is the throttle shaft. Over time it and the bushings it rides in will wear out. This allows air to leak into the carburetor, leaning out the mixture. At full or near-full throttle, this can usually be compensated for by adjusting the mixture, but at idle it can present problems—rough idling and hesitation as the throttle is opened. A separate throttle shaft and bushing kit is available if you choose not to overhaul the carburetor completely.

It is possible for the old-style hollow brass floats to develop a leak and fill with fuel. If this happens, they will sink and allow too much fuel into the float bowl, causing the engine to run very rich or even flood out completely. Since 2006, an unsinkable epoxy float has been available and is recommended. These can be purchased separately and come with retrofit instructions.

Service Bulletins

There have been dozens of service bulletins issued on Marvel-Schebler carburetors, some by Marvel-Schebler and

This is the deluxe repair kit for an MA-4SPA carburetor. It contains a throttle shaft and bushings, a new accelerator pump, a new idle mixture screw and a number of other parts and gaskets. If you also need new floats, that's a separate kit.

many more by Precision Airmotive, the company that made Marvel-Schebler carburetors for years. Certainly many, if not most, will not apply to your particular carburetor. Still, it would be wise to look over the list of service bulletins and make sure yours has been properly maintained. The easiest way to do this it to have your carburetor overhauled by a factory-authorized service center. That way there is no doubt that you are up to date on all the relevant service bulletins and ADs. Of course, if you bought a new engine you have no worries in that regard. Same for exchanging your carb for a factory-overhauled unit; it will be brought to the latest spec.

The big service issues that affect older carburetors are older floats that should now be replaced with the epoxy floats, worn throttle shafts and bushings, and those few remaining carburetors that still need one-piece venturis.

Airworthiness Directives

Marvel-Schebler carburetors have been subject to six airworthiness directives over the years. The most familiar one is probably 63-22-03 dealing with the venturi assembly. This AD directs the owner to inspect the carburetor to see if it has a one-piece venturi, and if it does not, to replace the venturi with a one-piece unit. You know the AD numbering system, so you also know that directive dates from 1963. There *shouldn't* be many of those older venturis still in circulation.

Another old AD, 69-24-03, directs the mechanic to drain the carburetor float bowl and look for thread lubricants. Only approved thread lubricants are to be used during carburetor assembly. AD 72-06-05 R2 calls for the inspection and possible replacement of throttle arms on some carburetors. AD 77-13-16 applies to only certain engines installed in Aero Commander 112TC and 112TCA airplanes. AD 79-08-06 calls for the replacement of certain HAJ-6 carburetors. These are horizontal intake or side-draft carburetors. I have never seen one of these carburetors except at the Lycoming engine school. And, finally, AD 88-02-04 warns of loose metering sleeves on carbs fitted to Lycoming O-235 engines.

All of these ADs are old enough that they should not be a concern anymore, but just because Marvel-Schebler says its carburetors should be overhauled every 10 years does not mean that this actually happens. If you are going to use an older engine in your airplane project, it is a good idea to make sure the carburetor has all of the current ADs and service bulletins completed.

This is when Experimental builders start saying, "We don't have to comply with service bulletins and ADs." That is true to a point, but not entirely. When you complete your application for an airworthiness certificate (Form 8130-6) you attest that all relevant ADs have been complied with. Your operating limitations, at least if they have been issued in the last few years, also bind you to manufacturers' life limits for all parts that have life limits, such as your carburetor. Last and certainly not least, your safety should be of paramount concern, making it pretty hard to ignore service bulletins and ADs that will have an impact on that safety.

Neglect is the biggest enemy of your carburetor. Take care of it and it will take care of you.

Here is my new Lycoming YO-360-A1A engine with an Avstar carburetor. I guess Marvel-Schebler's prices stimulated some competition. The Van's airbox made for an easy fit on my GlaStar project.

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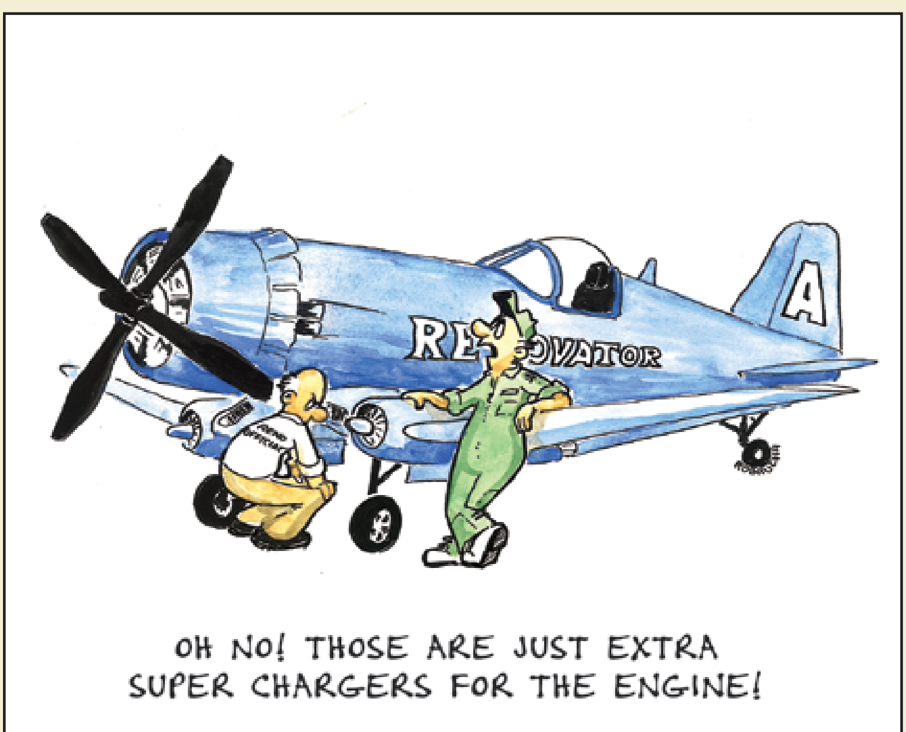
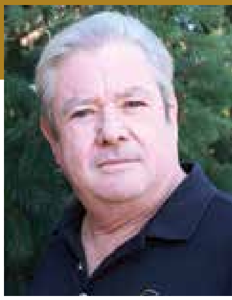




AERO 'LECTRICS

Vertical, Vertical and so Very Practical

So, here we are with fly-in season upon us. And fire season. And lots of reasons to have an aircraft com station on the move to get to the location of interest. Radios move easily. Not so most of our antennas.

Please, whatever you do, do *not* call that little rubber resistor that came with your handheld an antenna. A piece of limp spaghetti in a copper septic tank would give better results. I've done numerous side-by-side comparisons on a plain old single vertical zero gain antenna versus a rubber ducky, and the results are somewhere between -10 and -20 dB of loss on the duck versus the vertical. To translate that to power or range, let's say we have a 5-watt handheld transmitter with a 1-microvolt receiver. Or if you like, your handheld is trying to talk to an airplane 10 miles away. What is the effect of a simple vertical antenna versus the duck?

A loss of 10 dB on a 5-watt transmitter means that you are actually radiating half a watt (0.5 watts, or 500 milliwatts). A 20 dB loss means that you are actually radiating 50 milliwatts, which isn't enough power to blow your nose.

On the receive side, that 10 dB loss means that your 1-microvolt receiver is now a 3-microvolt receiver, and the 20 dB loss puts that up to 10 microvolts.

For distance, 10 dB of loss means that 10-mile airplane sounds like it is 30 miles away, and 20 dB puts it 100 miles away.

In either case, you've spent a fat chunk of change buying a nice radio

The order in which a solder-style BNC male connector should be assembled. From right to left: The body or shell, the male pin, the braid grommet, the compression gasket, the ring washer and the gland nut.

The antenna resonance tool for wire antennas (above). Make it too long and cut off what you don't need. I leave a short stub of coax on my portable antennas, then add a coax cable with connectors. My cables range in length from a couple of feet to a hundred feet (right). If you try to cut the coax on the antenna exactly to your current need, you will have to make another antenna for the next job. It's much easier to make a coax cable than a whole new antenna.

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.*

The assembled parts prior to final assembly (left). The male pin is soldered to the coax center conductor. Below it is about 50 mils of center conductor insulation, then the coax braid bent back around the braid grommet, then the rubber compression gasket, the ring washer and the gland nut. You can couple two male BNC connectors together with what is called a BNC barrel (above). You use one of these between the BNC male connector on the antenna and the BNC male connector on the long coax cable.

with a crappy (that's a technical term) antenna. Just for bouncing around the airport, that may not seem like a big deal, but if you are actually trying to communicate air to ground at a fly-in or during an emergency, you need something a bit better.

We will do a couple of designs, neither of which will cost you more than a Starbucks Caramel Macchiato Grande ($10). Both of them will be verticals because verticals are what we use for com in the aircraft band. One of them will truly be an in-your-pocket portable, and the other one will fit easily into the luggage space of a C-150 (or tucked into the back seat of a Long-EZ).

We will also make provisions to haul them up into a handy antenna "mast" like a tree branch or roof overhang. It is true that getting an antenna up into the air and away from the ground makes them perform a whole lot better. So, without further ado, let's get onto it.

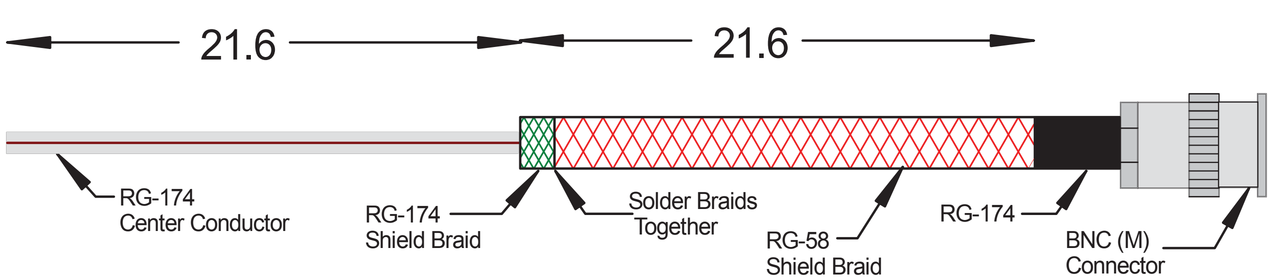
The first thing we need to do is pick our operating frequency since that will determine how long to make the antenna metal elements. I'm going to pick the frequency 122.725 MHz because that's the frequency of my home drome: Nevada County International Airpatch Unicom. Your frequency might be different, but the difference will be in fractions of an inch from one end of the aircraft com band to the other. And I'm going to do it in plain old eighth-grade arithmetic and not the algebraic notation stuff. All you need is a simple four-function calculator.

Here we go. The speed of light is 186,282 miles per second. 122.725 MHz can be written 122,725,000 cycles per second. Wavelength is speed divided by cycles, or 186,282 divided by 122,725,000 or 0.00151788 miles. Times 5280 feet per mile gives us 8.0144 feet. Times 12 gives us 96.17 inches. See? That wasn't all that hard, was it? Now, antennas are built on the "quarter wave" principle, so a quarter wave is 96.17 inches divided by 4, or 24.04 inches.

Permit me to add some black magic. For half a dozen reasons, antenna designers start off with a 90% quarter wave when using thin (#10 or smaller) wire. If this magazine were 200 pages long, I'd be glad to explain this phenomenon in excruciating detail, but if you will allow me to hand wave it, this means antenna elements 24.04 times .90 or 21.6 inches long. That's where we will start. See the images for my antenna tuning tool.

Since this first antenna is going to be shirt-pocket small, we are going to make it out of coax cable shirt-pocket small: RG-174, my coax of choice for anything below 1000 MHz and 10 feet of run. At the com band frequencies it has a loss of 1.5 dB per 10 feet, or a power loss of about 20% for 10 feet. If this is not acceptable, you can use RG-58 with a loss of 10% for 10 feet. Same construction technique.

I'm going to take a length of RG-174 coax 72 inches long and a piece of RG-58 24 inches long. Strip 22 inches of the outer black insulation off of the RG-174. Strip all of the outer black insulation off of the RG-58. Cut all but 1 inch of the braid at the remaining black RG-174 insulation. Peel all of the braid from the RG-58, slip it over the black insulation of the RG-174 and solder it to the short 1 inch of braid



A drawing of the small RG-174 coax cable antenna.

This is my workhorse for analyzing antennas (left). It was purchased in 1995 for $150 and has analyzed over 200 antennas here at the RST labs. It is my right hand for antennas. The coax vertical (right). It is nearly invisible both in the photo and in actual use. It makes a great stealth antenna.

remaining on the RG-174. Solder the two braids together.

Install a BNC connector onto the 2 feet of coax remaining and tune as described in the second to last paragraph. You can attach the tuned RG-58 antenna braid to the RG-174 black insulation by shrink sleeving *or* the homebuilder's perennial favorite adhesive—hot glue.

The advantage to this antenna is that you don't have to run the coax away from the antenna for a quarter of a wave like you do with a vertical dipole. The *dis*advantage is that it is relatively fragile and somewhat susceptible to contamination with water and other pollutants over time. It is also a bit more sensitive to being located close to the earth—it likes to be high up.

The alternative is a true vertical dipole with an arm that keeps the feed line away from the antenna. This one is made out of ¾-inch PVC water pipe and Romex house wiring for elements. The cost of making this antenna is 10 times that of the shirt-pocket antenna: $0.10 for the shirt antenna and almost (gasp) a dollar for this one.

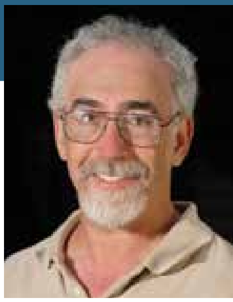
Please note…I've shown this design on PVC water pipe, which is what I had in the lab to work with. Cardboard? Plastics? Plywood? Any insulator? Not a problem and no modification necessary.

As with the shirt-pocket antenna, the adhesive of choice to keep the wire onto the surface of the water pipe is hot glue, and the sealant to keep the coax from becoming contaminated is the same hot glue.

Both antennas will work quite well with all of the elements at 21.5 inches long, but if you can get your hands on a VSWR meter, you can prune the antennas to precise length with the tuning tool shown in the images.

There you go, folks, two highly portable antennas for less than $2. Not a bad deal. See you next month, and until then…Stay tuned…


The coax at the T fitting on the PVC vertical (left). The braid is soldered to the copper wire element on the left, and the center conductor is soldered to the element on the right. The PVC vertical (right). Cyndi is holding it horizontally for the picture, but in use it must be held vertical. Note the short stub of coax coming out of the arm by Cyndi's right hand.



WIND TUNNEL

Design Process: Cantilever Wings

Last month we began our discussion of the structural layout of the wing with a look at externally braced wings. We now turn our attention to cantilever wings.

The majority of modern airplanes have cantilever wings because the drag penalty of external wing bracing is excessive for their mission.

On a cantilever wing, all of the loads are borne on structural elements that fit entirely within the airfoil contour of the wing. The wing will incorporate one or more full-span spars that carry the primary bending load.

There are two approaches to giving the wing sufficient torsional stiffness to withstand the torsion produced by the ailerons, flaps and the other aerodynamic forces that tend to twist the wing.

It is possible to use a single tubular or box spar that is stiff enough in torsion to carry the twisting loads as well as the wing bending. This approach has some advantages, particularly if the wings need to be easily removable for storage or transport (as is the case for most sailplanes), but it tends to be heavy because of the need to torsionally stiffen the primary bending spar.

The more common approach is to use at least two spars. The ribs and the wing skin span the area between the spars. The combination of the spars, ribs and skin form a lightweight, torsionally stiff box structure (commonly called the wing box).

For wing structure typical of general aviation airplanes, the forward spar is placed at or near the point of maximum thickness of the wing and carries all or most of the wing bending moment.

At the fuselage side, the designer has a choice of attach concepts:

The first attaches the wing to the fuselage only at the main spar with a single attach system that carries the lift, bending and torsion.

The second approach attaches both the main spar and the rear spar to the fuselage. The main spar then carries the majority of the lift and bending moment, and the rear spar is either shear-tied to the fuselage or carried through like the main spar to transmit the wing torsion into the fuselage.

Wing Carry-Through

By far the biggest configuration integration task for an airplane with a cantilever wing is carrying the wing bending moment across the fuselage. The configuration must incorporate a carry-through structure that can withstand the full bending moment generated by the wing.

For the majority of airplanes this means that there will be a carry-through structure inside the fuselage that is the same depth as the wing main spar.

It is possible to use an arrangement where the wing spar is butt-joined to a very stiff ring frame that carries the bending loads around the outside of the fuselage. This arrangement is called a side-tie wing, and it is used on some military fighters to carry the wing bending loads around the ducts and engine bay for jet engines incorporated inside the fuselage. Side-tie wings are rarely, if

The Junkers J 1 was the world's first all-metal aircraft and also the first to use a cantilever wing. Its first flight was December 12, 1915, only 12 years after the Wright brothers made the first successful powered flight on December 17, 1903.

Barnaby Wainfan

Barnaby is a Technical Fellow for Northrop Grumman's Advanced Design organization. A private pilot with single-engine and glider ratings, Barnaby has been involved in the design of unconventional airplanes including canards, joined wings, flying wings, and some too strange to fall into any known category.

ever, used on other types because the ring frames must be very strong, and hence very heavy, to carry the wing bending around the central hole in the frame. A side-tie arrangement will always be significantly heavier than a full-depth carry-through and is therefore only used when major components of the configuration cannot be integrated with a carry-through design.

When the Cessna Cardinal is loaded to its most forward CG, the mild nose-heavy condition is countered by an all-moving horizontal tail, which has enough control authority to keep the airplane in trim. *(Photo: aeroprints.com [CC BY-SA, https://creativecommons.org/licenses/by-sa/3.0])*

Fuselage Integration

The carry-through structure of a cantilever wing is as deep inside the fuselage as it is in the wing root. This means that somewhere along the length of the fuselage, a cross-ship path is needed for the carry-through.

The position of this structure is not arbitrary. The main spar of the wing is at or near the chordwise position of the maximum thickness of the wing. As we have already seen, the wing must be located on the fuselage in a position that puts the wing aerodynamic center close to the flight CG of the airplane. This leaves the designer relatively little freedom to move the carry-through forward or aft.

The primary issue the designer must resolve is the relationship between the wing carry-through structure and the occupants of the airplane. In order for the airplane to balance properly, the variable load (people, cargo and fuel) must usually be centered about the flight CG to minimize CG travel. This tends to put the occupants of the airplane in approximately the same fore-and-aft position as the wing carry-through structure. The designer must devise an arrangement of seating and wing position that allows the people to sit in the airplane and the wing structure to carry through intact. This integration presents different challenges for low-wing and high-wing configurations.

Low Wing

On a low-wing airplane, the carry-through structure is at the bottom of the cabin. On a four-place airplane with two rows of seats, the spar can run between the rows. The front-seat occupants (pilot and right-seat passenger or copilot) sit either ahead of or on top of the spar, and the rear-seat occupants are behind the spar. On a two-seater, it's common to run the spar just ahead of the seats so it passes under the crew's knees.

On larger, pressurized airplanes like airliners and bizjets, it's common to run the carry-through structure entirely below the cabin to keep the fuselage pressure vessel cross section circular and then add fairings to guide the airflow around and under the wing box.

Any arrangement that runs the wing carry-through structure under the seats or the cabin will likely force the fuselage to be deeper than the minimum height required to accommodate the occupants. Sometimes the fore and aft position of the carry-through can be adjusted slightly by using changes in wing planform, wing sweep or airfoil shape to move the position of the spar at the wing root forward or aft relative to the aerodynamic center of the wing. This is a relatively limited option, but sometimes a few inches can make a big difference in the integration of the fuselage.

High Wing

It's harder to integrate a cantilever wing carry-through structure on a high-wing airplane than a low-wing one. On a high-wing airplane, the spar must cross on the top of the cabin. This tends to put it in conflict with the heads of the front-seat occupants on a four-place airplane and in front of the crew on a two-seater.

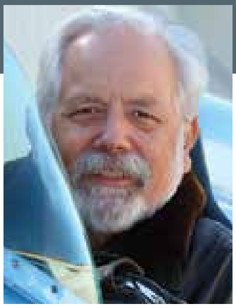
Either of these situations presents the designer with a problem. Obviously, the spar cannot pass through people's heads. Even if the spar is forward of the crew's heads, it's still a problem because it will be in front of their faces, obscuring forward visibility.

The designer has two choices: Make the fuselage deeper so the wing carry-through goes above the crew's heads, or try to get the front-seat occupants' heads forward of the carry-through.

Deepening the fuselage works well to help balance the airplane because it gives the designer freedom to move the wing fore and aft relative to the fuselage without conflicting with the occupants. The downside of this approach is that the fuselage will be a little heavier and draggier than it would be if the extra depth was not required.

Moving the front seats ahead of the wing carry-through allows the fuselage depth to be reduced, but introduces balance issues. The wing spar tends to be about at the flight CG, so moving the occupants forward places their weight ahead of the CG and tends to make the airplane nose-heavy.

This can be alleviated with proper design. A wing planform with a slight forward sweep of the spar, combined with an airfoil that has its maximum thickness further aft than usual, can move the spar aft just enough to allow the crew to sit ahead of the spar. The airplane will still be a little nose-heavy with heavy people in front and no one in the back, and it will have a bit more CG travel than if the spar went over the top of the cabin. The mild nose-heavy condition can be countered by providing a horizontal tail with a bit of extra control authority to trim the airplane when loaded to its most forward CG. Cessna used this approach on the Cardinal, and this need for extra tail power is why the Cardinal has an all-moving horizontal tail as opposed to the conventional fixed-tailplane plus elevator tail found on all of the other high-wing Cessnas.



REAR COCKPIT

On Getting Dark

Tyrants make memorable flight instructors, a good thing when the lessons being imparted need remembering. And I must say, my primary flight instructor was a very memorable man.

One recollection was after a late in the day winter's training session when he was filling out my logbook. Explaining out loud as his pen scrolled through the little black book's columns he said, "That was point seven daylight and three tenths night." The ground school instructor, a sweet but by-the-book wheelchair-bound woman who doubled as the mom-and-pa school's secretary and an often unwitting bit of mica between the boss's cathode and the boss's wife/business manager anode overheard his remarks and countered, "You know, Harry, it isn't officially night until a half hour…" which is when the boss-instructor raised up his head and his voice and in a conversation-ending flatness declared, "I'm the boy's instructor and if I say it was night, it was night."

And there the matter will lie for eternity as they're both gone now, but more importantly, Harry said it was night.

Which brings me to a far more recent occurrence, in fact, one we can label downright contemporary when allowing for publishing deadlines. I had taken the old box kite about 40 minutes north to check in on a bit of KITPLANES® business. This was deep into December, so the days were aggressively truncated and holiday visitations an enjoyable part of the proceedings. We made the rounds in the shop, then retired to the office to peruse the latest bits of hard- and software.

Now, this office being interior to the hangar, is a windowless bureaucracy where time runs unmarked, and when I thought to consider just how long I'd been visiting and how short the days were, I knew I was in trouble. The sun was long over the yardarm and plummeting to the horizon; worse yet an overcast had solidified, making sure any residual light left trailing over the horizon would make a beautiful scene atop the clouds for those airline pilots superior to the stratus, but hasten the gloom to we underlings below it. And I would most assuredly be flying below it.

Bidding a hasty goodbye and equally rapid engine start, run-up and takeoff, I circled the Starduster to above the nearby Class C airspace and set a heading for home. Trading gasoline for time, I let the 540 up front thrum at its favorite spot: 24 square and a bit over 18 gallons an hour, but all those wings and wires ensured we weren't going that fast—that is, fast enough to get to the home drome before the sun had completely left the scene.

Now, I'd landed the Starduster deep into the dusk maybe three times in the preceding 20 years, and each time I've sworn I wouldn't do it again. But there I was, victim of my own gabbiness and failure to manage time, losing another race with the sun. The only real difference was I was older and still just as dumb, and it was going to be darker than ever.

Sitting there alternately considering the irrefutability of my shortcomings and the equally inexorable advance of darkness, I set aside stomach-gnawing

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.

long enough to consider the beauty of the transitional hour. It's a time when I don't fly much, at least not far from the home traffic pattern, and then in different aircraft. And thus it's a period of both high interest and intrinsic beauty; the headlights below were crawling in rivers through the Southern California valleys while above the clouds projected a beauty that comes with the combination of something simultaneously so shapely yet dangerous. Pawing one-handed at the flight jacket's pocket, I retrieved the cellphone and managed the photo you see to the left. You have to admit, no matter how un-aerodynamic a biplane's structure, it frames the world wonderfully.

Home was recognized from afar by the rotating beacon, and I set up for an overhead approach to the 2180-foot strip. There was some light pollution from the nearby downtown, the dull glow of my instrument lights and just a reminder of a sunset in the clouds far to the west. It was about 25 minutes after sunset and I'm telling you, it was night. This was especially true due to the thick overcast, the huge, dark military base immediately west of the airport and most importantly, because I was there.

Landing the hose-nosed Starduster is always a procession of disappearing acts; the closer you get to the runway the more the outside world disappears. But at night with no landing light, so much more turns to black that much sooner and many of the little clues one takes for granted in daylight simply aren't there. There's no rotation of shadows across the wings to reinforce the idea you're turning, for example, and the sense of speed given by increasingly blurred peripheral vision when close to the weeds is replaced by a giant, implacable inkiness, a void where the familiar has gone missing and the imagination goes blank trying to replace it.

Of course, there was a slow trainer working the pattern, probably the only one that week, and fitting in behind him put me lower and dragging it in more than I would have otherwise chosen. But by happy providence this forced me into a final approach with a bit of a left slip for "visibility" around the cowling and a hair of power-on to control how downrange the now ballistic-feeling biplane would go before impact.

Blessedly—and this has proven a large mitigating factor when flying while most birds roost—there was not a breath of wind. The Starduster would thus glide down whatever rails I set it on and with a promise to float straight down the runway with no drift, other than the one I would inadvertently induce in my visual ignorance. I resolved to not move unless necessary.

The lights of town winked out behind me as base turned to final, my world reduced to the left-most green approach light at the runway's end and the first white light at the runway's left edge; and like a navy pilot trapping on the boat at night, it was all I needed. By keeping the green and white lights coming straight at me, I knew I wasn't under- or over-shooting the touchdown point, and as the lights grew farther apart I knew I was getting closer. By how fast and then faster they began to spread, I knew how much quicker I was getting to the runway, and then they disappeared under the lower wing just as I was pulling off what little power remained. I had to be over the runway and the stick came back into the flare.

Nothing. And then still nothing. Just darkness, save for the instruments glowing and then a growing quiet as the wind roar went to a murmur, a sense of precious lift bleeding away into the night as the quiet grew. She's really slowing…

Bump! Stick forward! And the nose drops to reveal an almost blinding array of runway lights perfectly centered along both sides of the nine feet of cowling before me. Keep pushing the tail up to see, oh so gently squeeze the brakes as with no wind she won't stop in time on her own. Finally, the elevators can't lift anymore, the tail settles, darkness regains its strength and the tailwheel slowly rolls. Yes, much darkness again, but the familiar sort of darkness of a man shuffling across his living room to the light switch.

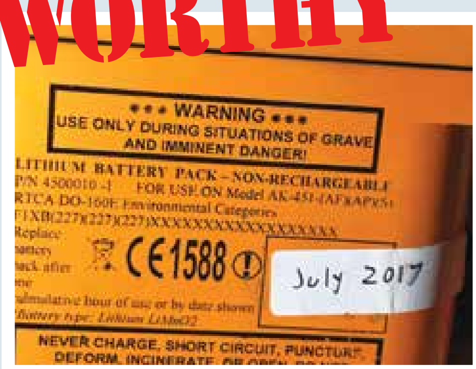
Don't do that again any time soon… but it was sort of neat. Landing lights for sure on the next build. ✈

UNAIRWORTHY

Past Due ELT Batteries

There is a requirement for an annual ELT check to be entered into the aircraft logbooks. The batteries must be replaced prior to the expiration date or when half of their useful life has passed. Some ELT battery packs are only made and approved by the manufacturer, and others can use standard D cell batteries. Both of these were discovered to be past due when they came in for a condition inspection. ✈

—Vic Syracuse



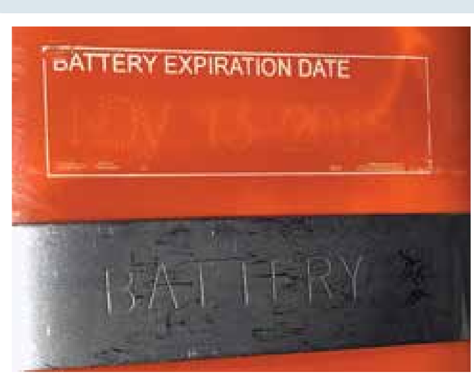


Photo: Tom Wilson

ARCHIVE

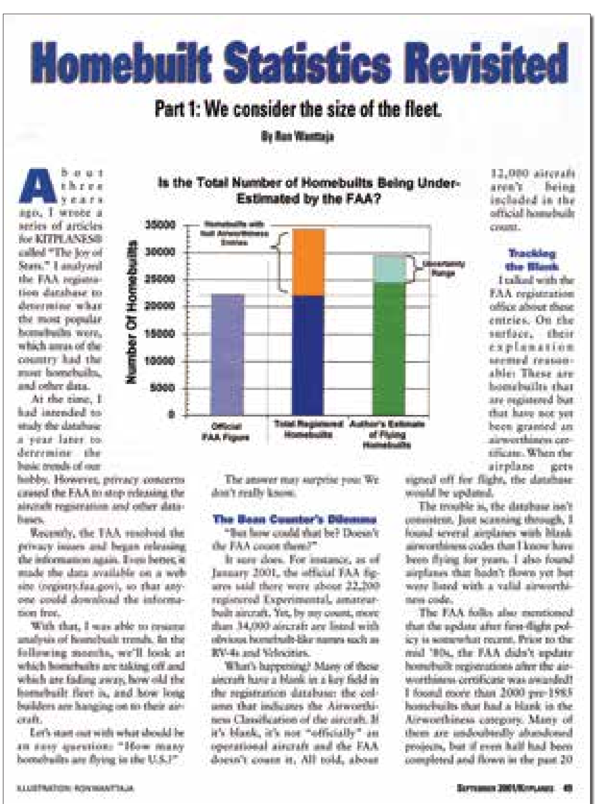
September 2001

Over the years, the Kitfox has been a frequent visitor to our cover. This issue had the Kitfox Lite Squared, which was to be the company's ultralight trainer. And by "company," we meant SkyStar, the owner that followed originator Dan Denney's Denney Aerocraft. At the time, SkyStar had the Kitfox Lite, a single-seat ultralight iteration of the design, the larger Series 6, which was capable of carrying engines as large as the Lycoming O-290, and the in-between Model IV.

For his review on the Lite Squared, John Larson described the aircraft like this: "Control forces on the stick were well harmonized. The flaperon force was comparatively light compared to other similarly equipped aircraft. I found myself flying hands off without thinking about it. The Squared was light, responsive and fun to fly." Larson flew the Rotax 912 version but one with a Rotax 503 two-stroke was also available. "What is a 100-hp engine doing in an ultralight trainer?" Larson asked in the review. "It demonstrates that the basic Lite Squared platform has the strength and controllability to handle this amount of power."

Elsewhere inside this issue, we reported on the first customer-built Lancair Legacy two-place taking flight. It was a much larger, much more powerful follow-on to the Lancair 320/360 line. It was owned by Carsten Sundin, Lancair's chief engineer at the time. Garmin's new GPSMAP 295 was featured, only the company's second full-color portable navigator. Lowrance and Magellan were still in the aircraft-GPS business, and UPS Apollo reflected the avionics line's interim ownership between founding company II Morrow and Garmin.

Proof that some topics are evergreen, our own Ron Wanttaja wrote the first of several features on homebuilt statistics, itself a follow-on to work he did three years prior, analyzing FAA registration data. Wanttaja estimated that there were just under 30,000 homebuilts flying, based on his analysis of the data. At the time, the FAA said there were 22,200 aircraft with Experimental/Amateur-Built marked in the registration. But when you added the aircraft believed to be homebuilts but with no E/A-B marker, there were nearly 35,000. His gut feeling? Just under 30,000 homebuilts were flying by early 2001. ✈



Homebuilt Statistics Revisited

Part 1: We consider the size of the fleet.

By Ron Wanttaja

About three years ago, I wrote a series of articles for KITPLANES® called "The Joy of Stats." I analyzed the FAA registration database to determine what the most popular homebuilts were, which areas of the country had the most homebuilts, and other data.

At the time, I had intended to study the database a year later to determine the basic trends of our hobby. However, privacy concerns caused the FAA to stop releasing the aircraft registration and other databases.

Recently, the FAA resolved the privacy issues and began releasing the information again. Even better, it made the data available on a web site (registry.faa.gov), so that anyone could download the information free.

With that, I was able to resume analysis of homebuilt trends. In the following months, we'll look at which homebuilts are taking off and which are fading away, how old the homebuilt fleet is, and how long builders are hanging on to their aircraft.

Let's start out with what should be an easy question: "How many homebuilts are flying in the U.S.?"

The answer may surprise you: We don't really know.

The Bean Counter's Dilemma

"But how could that be? Doesn't the FAA count them?"

It sure does. For instance, as of January 2001, the official FAA figures said there were about 22,200 registered Experimental, amateur-built aircraft. Yet, by my count, more than 34,000 aircraft are listed with obvious homebuilt-like names such as RV-4s and Velocities.

What's happening? Many of these aircraft have a blank in a key field in the registration database: the column that indicates the Airworthiness Classification of the aircraft. If it's blank, it's not "officially" an operational aircraft and the FAA doesn't count it. All told, about 12,000 aircraft aren't being included in the official homebuilt count.

Tracking the Blank

I talked with the FAA registration office about these entries. On the surface, their explanation seemed reasonable: These are homebuilts that are registered but that have not yet been granted an airworthiness certificate. When the airplane gets signed off for flight, the database would be updated.

The trouble is, the database isn't consistent. Just scanning through, I found several airplanes with blank airworthiness codes that I know have been flying for years. I also found airplanes that hadn't flown yet but were listed with a valid airworthiness code.

The FAA folks also mentioned that the update after first-flight policy is somewhat recent. Prior to the mid '80s, the FAA didn't update homebuilt registrations after the airworthiness certificate was awarded! I found more than 2000 pre-1985 homebuilts that had a blank in the Airworthiness category. Many of them are undoubtedly abandoned projects, but if even half had been completed and flown in the past 20

ILLUSTRATION: RON WANTTAJA

September 2001/Kitplanes 49

The Sherpa was still a thing in 2001 (above), while Ron Wanttaja was already looking at homebuilt registration data (left).

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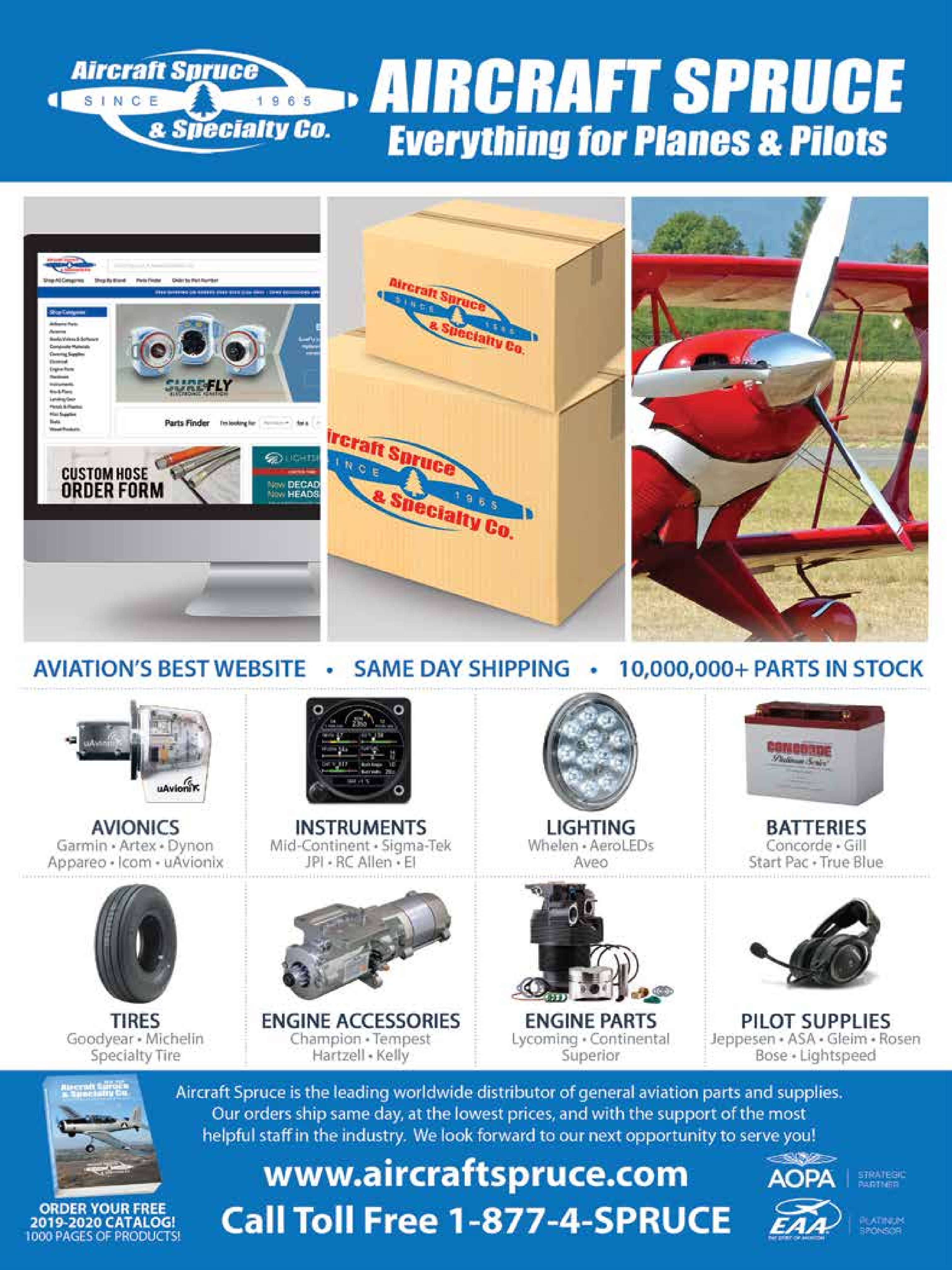
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