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KITPLANES
THE INDEPENDENT VOICE FOR HOMEBUILT AVIATION

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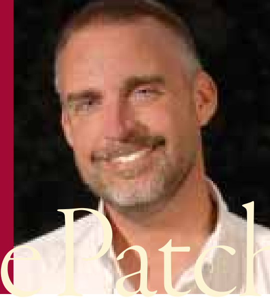


BY MARC COOK

Paying it back.

It seemed like a simple question. John Hammerstrand was helping a builder complete a Glastar Sportsman that had been started under the company's previous three-week Customer Assembly Center program. He was ever so slightly flummoxed by the aileron rigging. After discussing it over the phone for a bit, we decided a visit was in order. Could I come and take a look, and perhaps show a few tricks from my own example? Good thing he was in San Diego, California, less than a hour's flight from home. The promise of free lunch and a fine excuse to go flying tipped the balance.

Hammerstrand, ex-Navy navigator and longtime A&P/IA, had a thousand great questions about completing the Sportsman bolstered by an unquestionably can-do attitude. We walked around the in-progress Sportsman and he took copious notes and many photos of my completed airplane. I could appreciate how much had been done on the airplane but also just how much was left to be done. Several times during our visit, I returned to that dark January in Arlington, Washington, as I worked through the construction of my Sportsman. And here's the tell: I did so with a smile instead of a grimace, proof positive that the pain of building recedes with time.

Hammerstrand, taking photos and making notes.

Something else kept surfacing for me, the realization that we as builders are a small, special community and the critical element to keeping it all moving forward is just this kind of feedback and after-the-effort return to the community. While it's true that some builders complete a project and are rarely heard from again, I think that most of us are happy and eager to share our hard-won experiences. I know it felt great to offer Hammerstrand my thoughts on completion details for the Sportsman and more than a few "if I had to do it over again" lessons I learned during the construction of the airplane. Whether he chooses to take any of the advice is up to him, of course, but I feel better that I did my part by putting it out there.

On the same topic, a massive attaboy needs to go to Dave Prizio, the president of the GlaStar & Sportsman Association International (*www.glastar.org*)—incidentally, "Sportsman" is a new part of the organization's title, reflecting the popularity of the larger airplane and, perhaps sadly, the discontinuation of the two-seat model. Prizio stepped in to help not only Hammerstrand but also the first "civilian" builder to go through the Two Weeks To Taxi program, Richard Eastman, who took over my space at Chino when I moved N30KP to Torrance. Only the most cynical would suggest that Prizio's involvement is done to benefit his association; indeed, what I've seen from him is an inspirational example of a builder wanting other builders to create good, safe airplanes for the betterment of all. They say that a rising tide lifts all boats, and I believe that applies here.

I think if we all do our part to be a component of the after-completion fraternity, everyone benefits. Those of you building Van's aircraft have it easy; throw a rock at any half-decent size airport and you're likely to hit an RV flying or under construction. For those of us with less common aircraft, it's a little harder, but with the help of so-called type clubs, Al Gore's Magic Ones and Zeroes machine—nee, the Internet—and good word of mouth, anything's possible.

Marc Cook has been in aviation journalism for 19 years and in magazine work for 25. He is a 3800-hour instrument-rated, multi-engine pilot with experience in nearly 150 types. He's completed two kit aircraft, an Aero Designs Pulsar XP and a Glastar Sportsman 2+2.

Help Us Help You

Take a moment, won't you, to stop by our web site and take our online survey. Right now, we're asking your opinion on which airshows and events are your favorites, and what you hope to accomplish at them. (This month's is at *www.kitplanes.com/survey/airshow.htm*. Or look for a "Take the Survey" icon at the top of the home page.) In the months to come, we'll have surveys on airframes, avionics, engines and flying issues. Your responses help us make your magazine better and more relevant. Thanks in advance.

Photo: Marc Cook

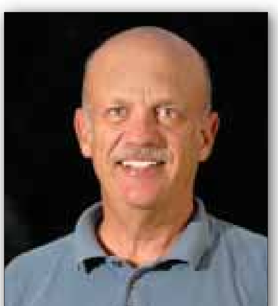
CONTRIBUTORS

LARRY ANGLISANO

Larry Anglisano is the Avionics Editor at *Aviation Consumer* magazine (another Belvoir title) and an avionics flight test pilot and inspector for an FAA Repair Station in Hartford, Connecticut. He's worked with general aviation avionics in certificated and Experimental aircraft for 20 years. In his off time—not that he gets much from *AvCon's* ruthless editor—he can be found piloting his Harley-Davidson. His feature on buying used avionics begins on Page 50.

RICK LINDSTROM

It's another busy month for longtime contributor Rick Lindstrom. First we get to follow his exploits building a Corvair-powered Zenith 601 (Page 28), in which the plucky Zodiac's feathers begin to grow. Next, Rick got to spend time with Reno air racer and raconteur Earl Hibler as he recalled the exciting gestation of the Discovery homebuilt. Good news on that front: We met with the new owners of the design, and signs are positive that it will make a successful comeback.



ED WISCHMEYER

We sent Tech Ed—our heretofore undisclosed internal contraction of his title and his name—to the front range of the Rockies this issue to fly with Aaron Hollingsworth in the Cozy Mark IV. Aaron now owns what was Nat Puffer's personal aircraft and the prototype of the design now held and supported by Aircraft Spruce & Specialty. Ed's flight report begins on Page 10—great reading and a wonderful example of the durability of Burt Rutan's design genius some three decades on.

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LETTERS

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Too Slow a Maneuver?

The article by Barnaby Wainfan in the May 2007 issue, "Wind Tunnel: Maneuvering in slow flight," while a great article from an engineering perspective, left out some real-world complications that could get people into trouble. Readers should not assume that they can select an appropriate approach speed by simply flying at 1.3 times the indicated airspeed at the stall. These additional aspects should be considered:

1. Airspeed system errors. Many aircraft have significant airspeed system errors at low speed. A landing reference speed (VREF) of 1.3 times the stall speed only provides the expected margin from the stall if it is based on calibrated airspeeds; i.e., multiply the CAS at the stall by 1.3, and then fly at this CAS. Many airspeed systems underread at the stall. If the IAS at the stall is multiplied by 1.3, one may be much closer to the stall than expected. For example, the Pilot Operating Handbook for the Cessna 182Q that I fly once in a while says the max weight, aft c.g. landing configuration stall is at 50 KCAS or 38 KIAS. If we fly at 1.3 times 38 KIAS, that is 49 KIAS. The position error chart says that 49 KIAS = 55 KCAS, or 1.1 times the stall speed. Pilots who tried to fly an approach at 49 KIAS would likely get a nasty surprise when they tried to flare.

2. Margin to stall. Transport category aircraft typically have stall speeds in the landing configuration in the range of 70 to 120 knots. A 30% margin above the stall represents a much larger margin in knots than a 30% margin above typical light aircraft stall speeds. If an aircraft encounters a wind shear during approach, there may be a loss of airspeed. A transport category aircraft that is flying at 30 knots above the stall speed is much more able to withstand a 15-knot loss of airspeed in a wind shear than a light aircraft flying at 15 knots above the stall; 1.3 times the stall speed might be OK for large aircraft, but it might not be enough for aircraft with lower stall speeds.

3. Although many large aircraft have a VREF that is 1.3 times the stall speed, pilots will typically use an approach speed that is 5 knots greater than VREF if the wind is calm, and even faster if the wind is gusty.

It is quite unlikely that very many amateur-built aircraft owners have the means to determine the calibrated airspeed at the stall. So there is no practical way to determine an approach speed that is 1.3 times the CAS at the stall. What is a fellow to do? I recommend that the approach speed be selected based on a series of flight tests. A recommended flight test procedure can be found on my web site at: *www.kilohotel.com/rv8/article.php?story=Selecting_Approach_Speed*.

KEVIN HORTON

Cable Call

The February 2007 "Aero 'Lectrics" column gives some rather low values for the loss of RG58 coaxial cable. Two of my sources show the loss at 100 MHz to be 4.6 to 4.9 dB/100 feet versus 3.8 dB, and 17.5 to 20.0 dB/100 feet at 1000 MHz versus 14.5 dB, which, contrary to the article's tone, shows RG58 does not compare well with the other listed coaxial cables. Probably one of the best coaxial cables available for use in our aircraft, to obtain finest performance with our expensive avionics, is the 0.25-inch Andrew FSJ1-50A Heliax (*www.andrew.com).* Its loss at 100 MHz is 1.8 dB/100 feet and is 6.0 dB/100 feet at 1 GHz, about half the loss as that shown for the other cables, and a third that of the RG58. It has a solid, corrugated outer conductor, which means that its leakage is so low as to be immeasurable; not so with the braided cables listed. This is important as leakage of RF energy through the porous braided outer conductor of the listed cables contributes to nulls in the antenna pattern and RFI-EMI into nearby wiring. This often shows up as annoying squeals during transmit on certain frequencies, along with distortion of voice transmissions. Even though the FSJ1-50A has a solid outer conductor, its minimum bend radius is given as 1 inch. As with the listed cables, its weight is a comparable 4.5 lb/100 feet. This outstanding coax needs to be known by homebuilders and avionics shops who would like to install cabling that will give the maximum range and clarity. A couple of dB can make the difference between clear and garbled communications!

PAUL LIPPS

eCFI Feedback

Great article! Ever since I first pushed the buttons on the GPS/autopilot in a Cessna 172, I wondered when someone would come up with at least a panic button. It seems to me that with all of our technology, passengers who are not used to any form of aircraft emergency but who could "drive" an airplane and our litigious society, a panic button like this would ease some stress and expand our sport tremendously.

Even if the eCFI system were set up to just fly the airplane and change the radio to 121.5 so ATC could communicate with the passengers, it would be a good thing. Most people I fly with know enough to respond to commands and to change the autopilot heading indicator at the appropriate time. They also know how to reduce power with ATC's help to line up with a runway and drive the plane on a 10-mile final. Of all your points, I think this would be the most simple and cost effective to install. Can't wait for the next installment.

GARY BUDZAK

You've probably already seen the second installment in the July issue, and the final one begins on Page 34.—Ed.

CONSTRUCTION HELP FOR COZY BUILDERS

Freeflight Composites, LLC has provided construction and maintenance assistance to builders/owners of canard-type aircraft for years. Now, in a new arrangement with Aircraft Spruce & Specialty, Freeflight will offer training and builder assistance to owners of Cozy plans and Cozy aircraft (Aircraft Spruce sells plans for the Cozy Mark IV design). According to Freeflight, Cozy construction workshops will be held twice a year and will feature materials, tools and techniques that can help builders get a jump-start on their projects. Transition training from a Certified Flight Instructor will also be available. Individual builder assistance may include sessions on component design and construction, electrical system design, and instrument panel design and construction. Shop rates for these individual programs are $50 per hour. Daily rates for builders who wish to use the Freeflight shop for construction are also available.

Estimated price for the three-day construction workshop is $395. For more information, call 719/660-8650 or visit *www.freeflightcomposites.com*. A direct link can be found at *www.kitplanes.com*.

WEB LAUNCH FOR LYCOMING

Lycoming Engines, a Textron company, recently launched a new web site for engine customers. Visitors to the new web site can expect to see key product features, easy searchability, an online company store, as well as information about the much anticipated "Thunderbolt Site and Engine Configurator," which allows visitors to select a powerplant option and see the base price, fuel system, horsepower, displacement and other specifications.

For more information, visit the new web site at *www.lycoming.com*. A direct link can be found at *www.kitplanes.com*.

ASPEN LOWERS PRICES

Aspen Avionics has announced a price reduction on its award-winning AT300 hazard awareness display. Effective immediately, the price is reduced to $2995 (a $1000 reduction). Aspen has been pleased by how the hazard-awareness unit has been received in the retrofit market. Says Vice President of Marketing Doug Cayne, "We're confident that this price reduction will make this important technology accessible to more pilots and aircraft owners."

For more information, call 505/856-5034 or visit *www.aspenavionics.com*. A direct link can be found at *www.kitplanes.com*.

AVIATION MAINTENANCE TECHNICIAN REFERENCE

Avotek Information Resources has announced the publication of the *Aviation Maintenance Technician Handbook*, part of Avotek's selection of maintenance training materials. Extensive use of illustrations and photos make this book an invaluable resource, the company says. Among the topics covered are composites, aircraft fabric, electrical systems, fluid lines, weight and balance, tools, hardware, etc. Reference tables include conversions, hydraulic relationships, and binary/decimal equivalents.

The price is $16.95. For more information, call 800/828-6835, or visit *www.avotekbooks.com*. Avotek books are also available through its dealer network at *www.amtbooks.com* or *www.kitplanesbooks.com*. Direct links can be found at *www.kitplanes.com*.

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BY JIM WEIR

Flash yourself, Part 2.

So we've come to the point in this project where we have about 3 joules of energy (100 microfarads of capacitor charged to 300 volts) ready to light up our lightning bolt in a bottle. Now it becomes our job to see how to make that lightning happen.

Here's the deal: 300 volts across an almost empty tube of xenon and vacuum isn't enough to start the flash going. However, if we put a very large (6000 volt) electric field over the *outside* of that tube, that will be enough to start the spark. Once the spark starts, it doesn't quit until that entire capacitor of charge is fully used up, and 3 joules of spark is a fairly bright light for a few milliseconds (see later comments).

Hold on a Second

So we went to all that trouble to generate 300 volts from 12 volts last month, and now you are telling me that we need to generate another 6000 volts? Yes, but only for a few hundred microseconds. Just like a real lightning bolt only needs a couple of hundred microseconds of "leader" to start the plasma discharge, so our miniature lightning bolt needs the same thing. Just start the spark and the xenon gas will take care of the rest.

This small flashtube was used for experimentation.

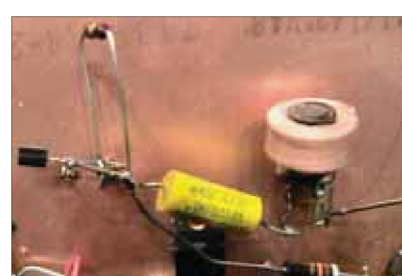
T1 in the accompanying schematic is the spark starter. If you give the primary of T1 (the left-hand coil) a shot of 300 volts for a few hundred microseconds, it will induce a 6000-volt pulse into the right-hand secondary. Pulse the primary, fire the secondary, start the arc (plasma) in the lightning bottle, and away we go.

That's not too hard. Charge up a decent size capacitor (C2, 100 nanofarads) to the 300-volt supply through R3, which should happen in about 5 milliseconds, and then snap discharge it. It will induce that 300-volt pulse in the primary, which reflects a 6000-volt pulse in the secondary.

Snap discharge? That sounds like a job for an SCR (silicon controlled rectifier), one of the lesser lights of the semiconductor arsenal. Most semiconductor devices are at least marginally analog. That is, you can put in a little voltage, and it will give you out a little voltage. Put in a little more, it will give you out a little more. Put in a lot, it will give you a lot out. SCRs aren't that way.

Put in a little voltage to an SCR, you get nothing. Put in a little more, nothing. Put in just a *little* more, and you get the whole power pile out—nothing held back. In particular (see the schematic) when the gate (the little arm coming in from the left) is less than a volt, the SCR does not conduct current at all. When the voltage rises just a few millivolts above a volt, the SCR all of a sudden conducts amperes of current instantaneously. Even if the gate voltage drops below a volt, the SCR keeps conducting until the voltage at the anode (the black pointy terminal) drops to zero—the very definition of a "bang-bang" switch.

OK, then let's figure out how to make our 300-volt supply trigger this little rascal. Actually, the 300-volt supply is adjusted (last month) to rise to 350 volts under no load. With no load being no current through the lightning bottle, the voltage at the anode of Q1 will rise from zero at turn-on to approaching



Left to right: the small black SCR, the yellow 100 nf flash capacitor, and the orange 300:6000 volt flash transformer.

Jim Weir began acquiring Aero'Lectrics expertise in 1959, fixing Narco Superhomers in exchange for flight hours. A commercial pilot, CFI and A&P/IA, Jim has owned and restored four single-engine Cessnas. These days, he runs RST Engineering and teaches electronics at Sierra College. Ask him questions at rec.aviation.homebuilt or visit his site at www.rst-engr.com/kitplanes.

Photos: Jim Weir

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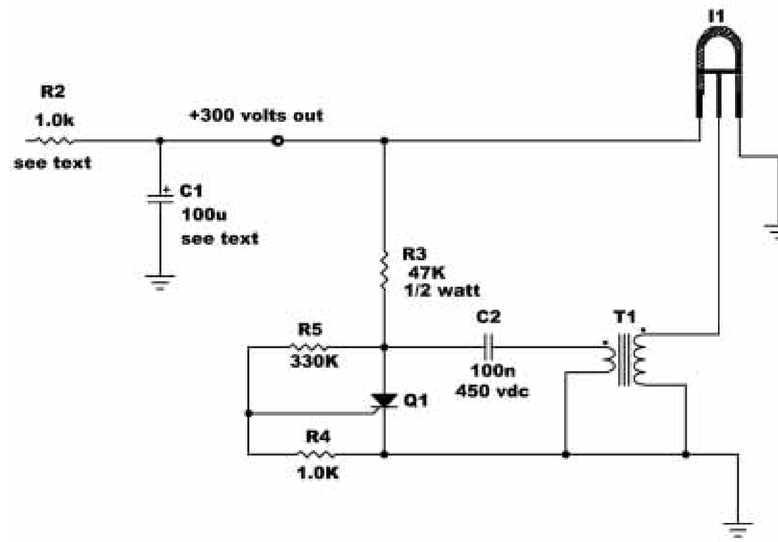
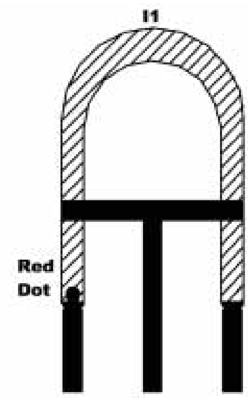
The schematic.





Reference Designator	Value	Mouser Part Number
I1	60-joule flashtube	36FT106
T1	300:6000 volt transformer	422-3306
C2	100nf 450-volt capacitor	146-630V.1k
Q1	400-volt SCR	511-XL08040

350 volts until the R4/R5 combination puts a volt on the gate of Q1 at 331 volts. BAM, the SCR turns on, discharges C2, T1 fires the 6 kilovolt bullet to the lightning bottle, and 330 volts is discharged in a few milliseconds through the bottle.

Then the good old power supply keeps on trucking and starts pumping C1 back up to 350 volts and when it gets to 330 volts, BAM...then BAM...then BAM. (John Madden, eat your heart out.)

Temporary Deficiencies

There is a downside to doing it this way. First, that strobe is bright, but not blindingly bright. I've been working on the top of the tailfeathers when somebody accidentally lit off the strobe, and *that* sucker is bright. Second, we are somewhat dependent on the battery voltage to set our strobe's repetition rate, and that's not good. That is, with a low battery voltage the strobe will appear to slow, as the power supply takes longer to charge the capacitor and thus fire the SCR. Third, we are wasting a lot of power in that 10Ω input resistor just to be sure that our power supply doesn't overvoltage and destroy the 100 µf 350-volt energy storage capacitor.

We'll take care of all these deficiencies next month. Right now, let me give you a source for all the critical parts we used this month so that you can at least get started playing around with this design.

Hey, for twenty bucks in parts, you can be up and messing around with things that are several hundred dollars from the parts houses. Not only that, but your replacement parts are measured in dollars, not dozens of dollars. Oh, and for those of you who have installed the commercial strobes and have had a tube go bad, you really might want to look at the Mouser line of flashtubes for less than $20 apiece. Now I would never tell you to replace a genuine aircraft part with some commercial equivalent, but I have this friend Ernie...

Next month: the ultimate strobe. Following? I dunno. How about the ultimate external GPS antenna (blatant commercial hucksterism), some thoughts on solar power for the hangar, and a few more goodies up my sleeve. Stay tuned. ✈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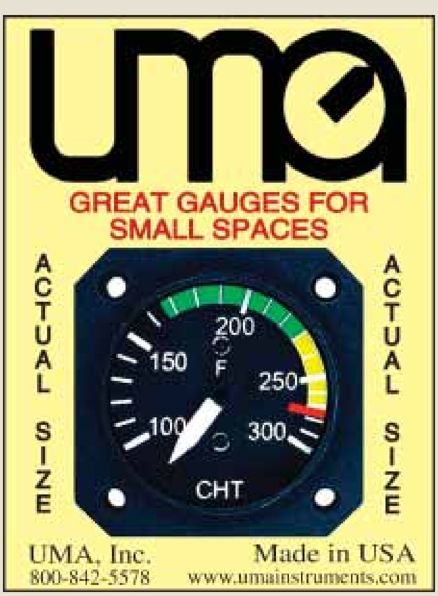
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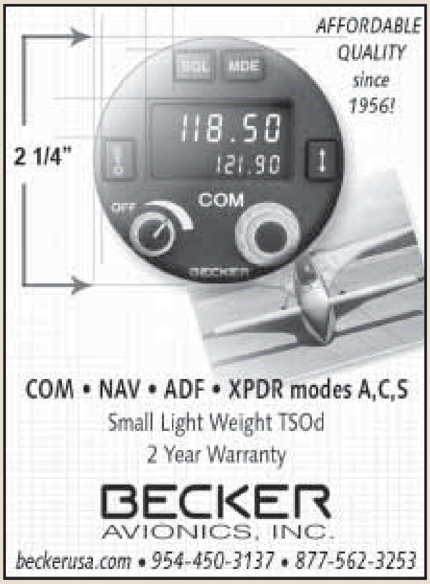
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Cozy Mark IV

Still looking as modern as tomorrow.

BY ED WISCHMEYER

Nearly four decades ago, when Burt Rutan began work on his VariViggen, something like the current crop of high-performance canards—of which the Cozy is a popular member—might have been difficult to imagine. Rutan's slab-sided, spruce-and-plywood VariViggen was the result of detailed model experiments, wind tunnel work and the kind of down-home engineering that has made Rutan an icon. (Testing a model of the VariViggen atop his station wagon is one example.) It helped prove the concept of stall-resistant design working alongside low drag and futuristic appearance.

The VariEze followed in the mid-1970s, with Burt's own example flying in 1975. It helped usher in the use of structural composites for a smooth surface and the ability to make shapes that would be either impossible or at least very difficult in metal. Workshops around the world resonated with the sound of sandpaper on longboards and the odor of hot wires cutting foam. Growth was inevitable, leading to the Long-EZ, which would become the most popular version of the two-seat tandem Rutan plansbuilts.

Room For More

Further growth brings us to the Cozy, basically a bigger fuselage on Long-EZ flying surfaces. There are actually two models of Cozy, the Cozy 3 and the Cozy Mark IV. The 3 is a three-seater, with one forward-facing seat in the back. The IV is a 3 widened by 4 inches in the front to 42 inches, and widened a lot in the back, to 38 inches. Baggage space was created by hollowing areas in the wing strakes.

Both models use the Long-EZ wing planform and airfoil, but the IV has 8 inches more wingspan and wing trailing edges turned up at the root. The 3 nominally uses the modified GU-5(11)8 airfoil on its canard, but the IV uses a Roncz R1145MS airfoil—more on that change and its ramifications later.

Homebuilding's answer to the Eclipse jet is, of course, the Eclipse Cozy.

The Cozy was conceived by Nat Puffer and was sold under license as a Long-EZ derivative. The plane we flew had been Puffer's personal plane, and was the first Cozy Mark IV built to plans. Aaron Hollingsworth, who owns the plane we flew, says there were numerous differences between the plans version and the Cozy Mark IV prototype—as would be expected. Many of the changes are to improve buildability. The intellectual rights have since been sold to Aircraft Spruce, which sells Puffer's design unchanged. Spruce hosts an online builder's forum, and is working on a promotional video with some stunning sights of the Cozy flying over the desert Southwest.

Spruce sells kits of two kinds. One has everything you need for each chapter of the assembly manual, and the other kit is grouped into hardware, fiberglass and such. A full set of sub kits organized by chapter is around $12,000, and a set of the other kits is about the same. The main difference is in how you care to plot the build. Either way, you get to make your own fiberglass landing gear. The canopy is normally bought from a third party.

Hollingsworth obviously enjoys his airplane and is plugged in to the Cozy community. When there was a question of which airfoils are used on the Cozy 3 and Mark IV and Hollingsworth did not have the answer, he pulled Puffer's number up on his cell phone and called him. And at his home field of Meadow Lake, northeast of Colorado Springs, is Freeflight Composites (*www.freeflightcomposites.com*), run by Cozy guru Burrall Sanders, an appropriate last name

Photos: Kevin Wing

for someone working on composite aircraft. Sanders' shop, attached to his airpark home, has seven composite airframes being worked on with two more in storage awaiting their turn. Aircraft Spruce refers builders to Sanders for completion assistance, and he is active on the Spruce web site.

Geared for Success

Many canards, like the Cozy, have fixed maingear and electrically retractable nosegear. With 100 hours of Cozy time, Hollingsworth knows the easy ways to lift the nose and maneuver the Cozy out of the hangar, extending the nosegear just the right amount to make the nose easy to lift without letting the empty plane get tail heavy.

With a checklist and great care, Hollingsworth preflighted the Cozy, at one point climbing into the cockpit and standing in front of the back seats to check the oil. Because the Cozy is composite and grounding can be a problem, Hollingsworth's gas caps have wires that go directly to the gasoline in each tank. He made alligator clip wire leads to connect the gas caps to the fuel nozzle.

Two areas get special attention on the preflight. One is the nosewheel, because on one flight, the wheel was not straight and the powerful electric motor jammed the wheel so tightly that it would not extend for landing. The landing was uneventful, but it did take a while to refinish the fiberglass.

The second item that gets careful attention on the preflight is the propeller. Currently installed is a Performance Propeller fixed-pitch, three-blade prop that looks gorgeous with its thin laminations. There is one layer of fiberglass over the entire prop, but the tips have three laminations. "For any of the canard pushers, it's a good idea to have a second prop," Hollingsworth says, so you can keep flying while one prop is being refinished. His other propeller is a Catto from a 200-horsepower Velocity, but it has too much pitch for the 180 hp in the Cozy.

The panel on this Cozy appears dated, but with all the advances in avionics these days, any panel more than a week old looks dated. Hollingsworth's solution is to build his own moving map, and he showed me a panel-mounted Windows computer and an LCD screen much brighter than those used in commercially available products. Once he has the new panel in, Hollingsworth intends to get his instrument rating in the Cozy. He travels a lot on business, and says that having that rating will make a big difference flying east over the plains. Flying west over the mountains, he says, you can always find a window in the weather if you're patient.

Burrall Sanders' Cozy 3 is underway in his shop at Freeflight Composites outside of Colorado Springs. There are six other aircraft being worked on in the shop, and two in storage.

Cozy? You Bet!

Once you're in, the seating position is, you guessed it, cozy. With one cushion instead of two, there was adequate headroom for my long torso, but shoulder room was touching on the inside, and the top of my outside shoulder was nestling the bottom of the canopy rail. Because it's hard to turn your torso in a reclining seat, it was difficult to look much over your shoulders, though I could see the vertical fins on each side with some effort. The gas gauges are clear plastic sight gauges in the back seat that, frankly, I never looked at. Out of sight, out of mind—and that's not a plus.

Taxiing out, we had the canopy open and a cool breeze in our faces. At the runup area, we were close to the edge of the pavement on the left side, and I was expecting a pivot to the right. With a turning circle that I wish we could claim for our pickup truck, Hollingsworth pivoted left. Noise-canceling headsets made noise a non-issue.

With everything ready, we taxied onto Runway 15 at Meadow Lake, elevation 6874 feet. The temperature was into the 40s, but we had 6000 feet of pavement ahead of us, and by mid-field, we were up and off at 85 knots indicated. The canard had enough lift to do its thing, and lots more speed than a wing loading of 20 pounds per square foot would otherwise require; loading at max gross is 23 psf. With the canard on the horizon, we climbed at 100 knots and 700 fpm, not bad at 7000 feet. As that would suggest, and the performance numbers verify, the Cozy is a cross-country cruiser not a short-field airplane, and, for that matter, not an aerobatic airplane.

Going Places

Performance is impressive for 180 hp. We saw a two-way average of 172 knots (198 mph) at 9500 on a cool day at 2580 rpm, and that's for a plane that can carry four people—if two of them are small enough to fit in the back seat. (Still, that's far from the claimed max cruise of 191 knots listed on the Cozy web site. We have no reason to think Hollingsworth's airplane is particularly slow.) Hollingsworth estimated the fuel burn at 8.5 gph—leaning techniques will influence the consumption rate of any airplane, but the O-360 typically uses between 9 and 9.5 gph at 75% power, rich of peak EGT.

The Cozy carries 52 gallons of fuel, call it 5.7 hours absolute so about four and three quarters with a smart reserve. That will get you from here to there nicely. Depending upon how well they're built (minimum Bondo) and how well they're equipped, Cozy payloads are typically 950 to 1000 pounds, leaving around 650 pounds' full-fuel payload. The back seat is for small people or large baggage. Hollingsworth has survived riding back there, but only because the flight was short.

One of the main performance limitations of the Cozy has to do with the lifting ability of the canard. The Mark IV's is 2 inches per side shorter than the Cozy 3's, and this is to give extra margin from a deep stall phenomenon encountered and fixed on an early model Velocity 20 years ago. What happened was that both wings, front and back, stalled, and the Velocity descended vertically in a stable, unrecoverable configuration with no forward airspeed. This has not been encountered on the Cozy, but just to make sure that it won't happen, especially on a poorly constructed example, the canard is clipped, essentially guaranteeing that it will stall before the main wing does.

The downside of this is that with a smaller canard, it's harder to lift the nose on takeoff. The GU airfoil has more lift at low speeds than the Roncz, and that's part of the tradeoff. The downside of the GU airfoil is that when contaminated with water, its lifting ability is diminished. Hollingsworth says that the water contamination sensitivity is almost binary: Either the airfoil is wet or dry, contaminated or not, generating normal lift or not, with nearly instantaneous transitions between the two states.

Beers Before Launch

Another part of the pitch equation is ballast. If Hollingsworth wants to fly the Cozy solo, he makes sure that he gets a few cans of Coors Light in first—as in first to lift off at the front of the airplane in a ballast area. If he forgets the cans, which are filled with lead shot and epoxy, the Cozy is easy to over-rotate. Conversely, leaving full ballast in with two people up front would do bad things to the takeoff roll. Part of the reason for Hollingsworth's careful preflights is that he has a partner in the airplane, and he won't necessarily know exactly how his partner left the airplane after the last flight, especially with regard to ballast.

Right after takeoff, I took the controls and met the ailerons. On the original VariEze, the control surfaces on the canard were set up to provide both pitch and roll control, a nifty idea that really simplified control linkages because it wasn't far from the front stick to the moving surfaces. The only trouble with this idea was that it didn't work well, and so ailerons were put on the main (back) wing.

Those wing-mounted ailerons have a curious feel to them, however. It doesn't take much force to get the first increment of roll rate, but it's not a slow roll rate, it's a moderate roll rate. It's not as bad as all or nothing, but it's like asking for a teaspoon of roll rate and getting a cup. Adding in a lot more stick displacement gives little additional roll rate compared to the initial one.

Hollingsworth (who has not yet flown with the RV pilots on the field) and other canard pilots fondly refer to this as "sporty" handling. A CFI might express this as "challenging." An engi-

Transoceanic it's not, but the Cozy has solid cruise performance. It needs long runways, relatively speaking, but has great crosswind capability in the right hands.

What's in the Box?

Many kit aircraft have manufactured parts that are assembled. The Cozy kits are instead materials from which you manufacture parts, especially fiberglass parts. You can buy kits grouped of similar materials (all the fiberglass in one "kit," foam kit, metals kit, etc.) or you can buy kits that have everything you need to complete a chapter in the assembly manual, such as canard, elevators, nosegear. Either set of kits will give you almost all of the airframe. Wheels and brakes are included, but not canopy or cowl, which can be bought from third parties. Ready to assemble metal parts are also available. Not included, as on most kits, are engine, propeller, instruments, interior, paint and full electrical system, and most of those are available from Aircraft Spruce & Specialty. But rest assured that the finishing kit includes lots of sandpaper.

—E.W.

neer might say that the breakout forces are high relative to the roll input forces required, but feed him a few beers to get his guard down, and he might call them "twitchy." As Hollingsworth puts it, the ailerons "inspire pilots to do things they shouldn't."

I managed to befriend the ailerons, mostly, but it took concentration, like trying to be cordial with somebody who's mad at you. Even with the effort to become familiar, the ailerons surprised me on one landing. I was concentrating hard on airspeed, altitude and energy management, so hard that only the second string gray cells were worrying about roll, and I actually got into a pilot induced oscillation (PIO) in roll. This is the reverse of the traditional high-workload landing scenario in which pilots get into a PIO in pitch, while the roll behaves itself. Some of this was me, but a lot of it was the airplane. Despite plenty of time in type and a nice touch in canards, Hollingsworth admits that when he's on a cross-country flight and paying attention to other things, sometimes the aileron response zaps him out of the blue. I suspect that at least part of the fix would be to get absolutely all the friction out of the aileron linkages with ball bearings. The system now is push-pull tubes, but the bearings are Delrin.

And Now for Pitch

Pitch handling is not difficult, but it is also different. Trim makes a world of difference in flying the airplane, and works on this airplane with an electric motor adjusting spring tensions. The trim motor speed at cruise is too fast for the uninitiated on a first flight. Hollingsworth says that on cross-country flights, he can go a half hour without touching the elevators, letting the autopilot keep the plane headed in the right direction. However, he admits that he'll adjust the trim four or five times on takeoff and initial climb as the plane accelerates.

Pitch pointing tasks—raising or lowering the nose to a predetermined attitude—were easy. The stick-free stability tests were interesting, in comparison.

A rare front quarter view of a Cozy. Many planes would only see a rear quarter view, diminishing.

To perform those tests, the airplane is trimmed for a given speed. Then the stick is pushed forward or pulled back to give an airspeed change of 10 knots, and the stick is released. The point is to see how many cycles of higher and lower airspeed the plane goes through before it returns to the trim speed.

On the Cozy, the airspeed eventually settled to near, but not at the initial speed. Even more curious, after, say, pulling back on the stick to lose 10 knots, the Cozy would lose more speed before starting the nose back toward neutral. The bottom line is that the pitch handling seemed fine, and the Cozy may have "flunked" the conventional pitch stability tests because the static source is in the fuselage, near the rudder pedals, and as the angle of attack changed, the static pressure changed, giving bogus instrument readings. Also, the springs may have been masking some friction in the elevator linkage, which contributed to the results.

Canards aren't supposed to stall in a conventional sense, and when I held the stick back for high angle of attack flight, we got a mild nose porpoise as the canard stalled and recovered. Hollingsworth said the bobbing was much more pronounced with me up front than it is when the plane is flown solo.

Back to Home Plate

Hollingsworth let me attempt half a dozen landings, and it was clear that you'd want transition training in a Cozy if you didn't have any canard time. Pattern speeds are high at 90 knots downwind, slowing to 80 and then 75 on short final, comparable to a Cessna 210. The glide is fast and flat, but if you don't lower the nose in turns in the traffic pattern, the airplane can develop extra sink rate, though some of that may have been a persistent downdraft on base leg. It's tempting to fly a fast, flat approach, but that's poor technique and gives the brakes a workout.

After I commented that the Cozy would be a terrible plane to use for a commercial flight test with its requirement to land within 200 feet past a line, Hollingsworth demonstrated such a landing, no problem. But if you do what it takes to touch down on a point, you might end up with extra energy for the brakes to burn off, and vice versa. Also, you don't want to flare the Cozy like you would a conventional airplane—arrest sink rate and let it roll on. Don't try to hold it off. Part of the landing drill is to put down the belly board for more drag. It helps, but it doesn't seem to make nearly the difference that 30° of flaps does in a Cessna. However, it does affect the cowling airflow and makes the heat muff on the exhaust work lots better.

Once on the ground, Long-EZ drivers leave the speed brake extended to protect the prop from debris kicked up by the nosewheel. Cozy drivers retract the speed brake to get more cooling air into the engine, because the Cozy doesn't have a P-51 style scoop; it has a big NACA duct on the bottom of the aft fuselage to gather cooling air.

Leistung
[PERFORMANCE]

Life Is Good

Most of the satisfaction of owning and flying an airplane comes not from flying a plane with textbook handling characteristics, but rather from knowing and flying a plane really well. Hollingsworth does this. He has a nice touch and really knows how to make the Cozy do what he wants it to do. He's knowledgeable about the airplane and has the skills to become a really sharp CFI, should he choose to go that route. But for now, he has a plane that he knows thoroughly and flies beautifully. Add a (realistic) 170-knot cruise on 180 hp, ample payload, undeniable sex appeal...and life with the Cozy is good. ✢

For more information on Cozy IV plans and subkits, contact Aircraft Spruce & Speciality, 877/477-7823 or visit www.aircraftspruce.com.

COZY MARK IV

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Estimated build time	2500 hours
Number flying (at press time)	351
Powerplant	Lycoming 0-360, 180 hp @ 2700 rpm
Propeller	Performance Propeller three-blade, fixed pitch
Powerplant options	160 - 200 hp

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Typical useful load	1000 lb
Full-fuel payload	696 lb
Seating capacity	4
Cabin width	42 in
Baggage capacity	75 lb

PERFORMANCE

Cruise speed	220 mph (191 kt) TAS 7500 ft @ 75% of max-continuous, 9.5 gph
Maximum rate of climb	1200 fpm
Stall speed (landing configuration)	82 mph (71 kt) CAS *
Takeoff distance	1700 ft
Landing distance	1300 ft

** Cozy does not list a stall speed for the Mk. IV. This figure comes from the CAFE Foundation's test of a customer airplane in 1998 using a calibrated barograph. The stall speed comes at 1903 pounds, 47 under maximum gross. Otherwise, specifications are manufacturer's estimates and are based on the configuration of the demonstrator aircraft. As they say, your mileage may vary.*


1
DETAILS


2

1. The Cozy cockpit with side sticks. Rudder pedals actuate the brakes toward the end of their travel. Hollingsworth is building his own glass panel—his own hardware and software, that is. 2. The Cozy Mark IV uses the Roncz airfoil for greater tolerance of surface contamination. In other words, with this airfoil there is no pitch-down in rain. 3. If the flying surfaces look like Long-EZ parts, that's because they are. Bonus points if you detected the extra 8 inches of wingspan. 4. The Performance Propeller from Patagonia, Arizona, has thin laminations and a layer of fiberglass over everything. The tips have three layers of fiberglass. 5. Climb aboard! Lower the nose by retracting the nosewheel, step over and onto, and slide under the instrument panel.

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FLIGHT REVIEW

InTOXOcating

CAG's Toxo Sportster points to bullish times in the SLSA market.

BY GEOFFREY P. JONES

A Sportster you would expect to be just that: lively, racy, thrilling and exciting. This is exactly what the Spanish two-seat Composite Air Group (CAG) Toxo Sportster is. Fingertip control, a blast on just a Rotax 914 engine and good-looking to boot. Now the Zaragoza-based company has gone one further and carried out significant modifications so that it will comply with America's burgeoning Special Light Sport Aircraft (SLSA) category. The Toxo model on which the Sportster LSA is based is capable of cruising at 135 knots on 115 horsepower (from a Rotax 914). But for SLSA compliance, things have been moderated a little, including substitution of the more standard 100-hp Rotax 912 engine, which should help reduce the price and be sufficient given the mandated maximum speeds in LSA.

Where It Began

Behind all of this is CAG, a small company that started at Ribadeo in the Galicia region of northwest Spain in 2000, but which has received assistance from BAe Systems and in 2006 moved to a large and prestigious new factory on the Villanueva de Gallego Airport north of Zaragoza. With city and regional development funding, the company's setup would put most SLSA manufacturers to shame. Juan Carlos Ortiz, formerly of Embraer and Sikorsky, has joined CAG as its CEO and general manager to give "direction" and "commercial impetus" to the company. By the end of 2008, CAG hopes to have received from the European Aviation Safety Agency (EASA) its VLA (Very Light Aircraft) certification for the Toxo Sportster

For those of you who think the Toxo looks too much like a Glasair, here's your proof that it's not: Prepreg fiberglass is used extensively, where the American design is a molded wet-layup design.

Spanish, you say?


Free swiveling nosegear is standard. The maingear is a composite structure.

design and the production facility. Test-flying of the new Toxo Sportster SLSA commenced in late February.

CAG built and delivered 19 examples of the predecessor Toxo, 16 of them complete aircraft and three kits. None has been imported to the U.K. or built there, but they have gone to customers in Spain, Brazil, the U.S., France and Germany. A kit version of the Toxo will still be available, but CAG's dominant focus is on shipping completed Toxo Sportster SLSAs to the U.S. market. To that end, the company already has three distributors. In two years' time, CAG hopes to be rolling out one Toxo per working day from its Zaragoza factory, most of them containerized for shipment worldwide. One of its design staff—from a current total staff of nearly 50—is working almost full time on designing the packaging options to get four airframe-complete SLSAs into a standard 40-foot shipping container. Part of the design philosophy has been accordingly geared toward the Toxo's components. The tail height and the detachable horizontal tail surface help maximize shipping efficiency.

Wing Changes, Improvements

To achieve the required 45-knot clean stall speed, the Sportster's wing area was increased from 94 to 138 square feet, bigger in both span and chord. The cabin is wider than its predecessor's as well. CAG is aiming the Sportster at the top end of the market, with a nicely appointed leather interior as an option along with OP Technologies dual-screen EFISes.

A big negative for CAG at present is the euro/dollar exchange rate, but CAG is selling the Toxo at U.S. dollar prices and will honor its quoted prices despite currency fluctuations. Current base price for a factory complete Toxo is €96,813, or $131,878 at the exchange rate as of late April 2007. For €124,000 (approximately $163,000) you get everything, including the OP Technologies suite.

Flying It

Access to the cockpit of the Toxo Sportster (not the new SLSA version) involved stepping up onto the wing-walk and then onto the seat—not too bad, but it will improve. You slide down from the seat into a prone seating position, remarkably comfortable after the "sit up and beg" of Cessna singles. With 14 gallons in each wing tank, an additional 4 in the header tank, two people and 66 pounds of baggage we're at the Spanish


While the demonstration aircraft was fitted with a turbocharged Rotax 914, the U.S.-bound SLSA version will carry the popular 100-hp Rotax 912S.

Photos: Geoffrey P. Jones

maximum takeoff weight (MTOW) of 750kg, or 1653 pounds. Empty weight is 394kg, or 869 pounds. At the LSA-legal reduced maximum gross weight of 1320 pounds, and assuming little to no weight creep with the big wing, useful load will be a mere 264 pounds. However, Toxo claims the SLSA version will come in at a more reasonable 836 pounds empty and will carry just 21 gallons of fuel, making the useful load closer to 361 pounds.

The Rotax takes about 5 minutes to warm to its safe operating temperature. Without flaps (it's a cold, crisp Sierra day at 900 feet MSL), the propeller adjusted to takeoff and with little wind, I estimate the takeoff run at 700 feet. Rotation is at 50 knots, and immediately you have to remember not to over-control the Toxo's stick—just finger and thumb lightly as you allow the airplane to accelerate to the best climb speed of 90 knots. The VSI indicates 1000 fpm, and before we know it we're at maximum operating height in this area, 1000 feet AGL. Remember that this is the factory Toxo with the turbocharged 914 and an adjustable-pitch prop; the LSA version will have a fixed-pitch prop and 15 fewer horsepower. Toxo claims a maximum climb rate of 1000 fpm, which seems reasonable at the LSA's lower maximum weight.

The top-of-the-line panel will use OP Technologies EFIS main displays with some steam-gauge backups.

Checking Performance

I head north for some basic handling, and with 31 inches of manifold pressure and 5000 rpm we achieve a 75% cruise and 130 to 135 knots true on 6 gph, according to the EFIS. Reduce to 65% and the speed slips to 128 knots true, with fuel consumption of 5.4 gph.

In all maneuvers, the Toxo was stable, and in 45° banked turns little rudder input was required. With throttle up and 85° of bank we could turn almost on a wingtip, requiring a firm rudder input, but still with full control and minimal stick. The stall came at 52 knots IAS, flaps up. It is not dramatic, there's no pronounced wing drop, and I sense there is controllability throughout. Dropping the nose we lost only 100 feet. It's the same with flaps at varying settings—on this aircraft they are set at 10, 30 and 35°. You can choose your intermediate settings at 12 and 24 if you prefer, but the maximum must always be 35°.

In the pattern the Toxo is probably harder work than average, but that's a function of its slipperiness. It's good discipline to get your speeds and configurations correct. The white arc flap limiting speed is 95 knots indicated, so to slow down a high nose attitude along with throttle reduction are required. You also need to adjust the propeller again, but this won't be a problem in the SLSA version because it will only have a ground-adjustable prop.

I fly the approach at 65 to 70 knots

TOXO SPORTSTER

Price	$131,878
Number flying (at press time; all types)	19
Powerplant	Rotax 912S, 100 hp @ 5800 rpm
Propeller	three-blade ground adjustable

AIRFRAME

Wingspan	35 ft
Wing loading	9.59 lb/sq. ft
Fuel capacity	21 gal
Maximum gross weight	1320 lb
Typical empty weight	836 lb
Typical useful load	484 lb
Full-fuel payload	361 lb
Seating capacity	2
Cabin width	42 in

PERFORMANCE

Cruise speed	138 mph (120 kt) TAS sea level @ max-continuous power
Maximum rate of climb	1000 fpm
Stall speed (clean)	52 mph (45 kt) IAS
Takeoff distance	396 ft
Landing distance	578 ft

Specifications are manufacturer's estimates and are based on the configuration of the demonstrator aircraft. As they say, your mileage may vary.

CAG has invested heavily in accurate production tooling.

with 10° of flap and a good view over the nose, aiming to touch down at 52 knots. The Toxo sits low on ground, at least compared to my Robin, and it was tempting to flare too early. Next time around it was much better, and the little Toxo settled nicely onto the runway before I practiced another circuit. The Toxo has a castering nosewheel and dual toe brakes operating hydraulically to the two mainwheels. I sensed the start of a slight shimmy, but could not repeat it.

The main undercarriage legs are tubular steel and bolted to the main carbon-fiber U-shaped mainspar (the old spar was I-shaped). In the new SLSA version the balancing fuel tank will be replaced by the emergency parachute, and slap bang in the middle of the panel upper combing there's the red pull knob should disaster strike.

CAG has decided that the Rotax 912 will be the standard engine. The engineers dabbled during development and fitted the Jabiru 3300 in a couple of examples, but decided there would be too many changes between individual aircraft to justify this option. All the composites for the Toxo are manufactured at the Zaragoza factory, which has its own oven and paint shop. All component jigs are airline grade and heavy duty, just waiting for the green light on series production. Metal fittings are subcontracted out to another Spanish manufacturer.

This is a critical stage for CAG, with a huge investment and what looks to be an excellent product. The SLSA will obviously have to prove itself in the growing U.S. market. Whether the Toxo Sportster will penetrate that market sufficiently to meet the company's ambitious targets only time will tell. ✈

Cross-Country Crapshoot

The inside story of the development of the Discovery/Freebird Extreme...now Discovery. Bottom line: A little adventure is great! A lot isn't.

BY RICK LINDSTROM

Without fanfare or any sort of warning, the engine died. At 5500 feet MSL, and within spittin' distance of the 1991 EAA Oshkosh fly-in, the new Discovery prototype had once again resumed the role of unintended glider. The crew in this revolutionary new design consisted of pilot Earl Hibler and company owner William (Bill) Shaw, who up until a moment earlier, thought he was being dropped off in Green Bay before Hibler continued on to Wittman Field.

Given the sudden change in circumstances, and after a round of unproductive powerplant troubleshooting, Hibler pulled the nose up to recover whatever altitude he could while stopping the windmilling prop to eliminate drag. Hibler and Shaw needed an airport—right now—but there was nothing visible below but water and trees. It was time to ask for a little navigational assistance.

Fortunately, Hibler had been getting VFR flight following from Green Bay Approach, who advised that Courtney Plummer Airport in Winneconne, Wisconsin, was at 12 o'clock and 12 miles. Because this wasn't the first time the aircraft was being flown by Hibler as an ad hoc motorglider (sans working motor), he thought he just might could maybe make it.

Not Your Typical Airplane

Initially described as a "three winged airplane," the Discovery's design can be loosely traced to Burt Rutan's Eze series, which was instantly popular with both builders and pilots when the kits were developed almost three decades ago. There are many similarities between the two, including a pusher engine, fixed main and retractable nosegear, a canard forward and a swept wing aft, and composite construction.

There are significant differences as well, including spacious side-by-side seating, two large vertical fins supporting a generous horizontal stabilizer and elevator that relegate the small canard to being used for trim. There's sufficient space for baggage, giving the Discovery a higher level of utility for cross-country missions.

Originally designed for the Lycoming O-360, the Discovery could cruise at 170 mph while burning less than 10 gph. Gross weight with the 180-hp Lycoming is 1620 pounds, allowing for a payload of

The semi-reclined position of the Discovery's crew seats makes for comfortable cross-country legs. Originally designed with dual sticks, a single center console-mounted stick is currently under consideration.

760 pounds. Subtracting 176 pounds for a full-fuel load of 30 gallons, the Discovery still has 584 pounds of useful load available for a crew of two and bags.

And then there's the visibility, which can only be described as panoramic. The wraparound canopy, sloping nose and rear wingroot provide the crew with an unobstructed view above, down, forward and to the sides. In fact, it takes some neck-craning to even see the wingroots from the cockpit, since they start significantly aft of the seatbacks.

With such an innovative design, the Discovery showed promise as a safe, efficient cross-country speedster. With Shaw's assets now on the line, the race was on to build the prototype, display the airplane at Oshkosh and write up orders before funding ran out. All that was needed was the team to make it so.

Home Boys, California Style

With entrepreneur Shaw providing the capital and noted aeronautical engineer and designer Martin Hollmann providing the expertise, the Discovery went from concept to prototype in just two years. Based at the Salinas Municipal Airport in California, the project relied heavily on local talent to come to fruition quickly.

Other nearby Discovery team members included Rich Trickel, then head of Tri-R Technologies in Oxnard, who provided the molds for the Discovery airframe as he was doing for his own KIS line of kits. Reno race pilot Hibler was providing his A&P expertise to California Microwave at that time, building an unmanned, remote-piloted vehicle for the military called the CM-44B. This RPV also used airframe components from Trickel's Oxnard shop, which is where Hibler first met composite guru Chuck Harrison (who was working for Trickel during that time).

Harrison described the Discovery project to Hibler during a random visit, and Hibler, always up for a new aviation adventure, was then introduced to Shaw. After a brief confab, Hibler signed on to help test-fly the prototype, and the countdown started ticking toward the Discovery's debut at Oshkosh in 1991.

Working Out the Bugs

Hibler began flight-testing the Discovery in late April 1991, giving the crew a few months for any needed troubleshooting before the EAA convention deadline in July. As it turned out, there were some significant issues to be worked out before the project could be considered a success. "I took it up, and at about 100 knots, the airplane started rolling to the left," Hibler recalls about that first flight. "You'd be holding full right aileron, and the airplane would just keep rolling to the left. So you'd have to pull the power back and slow the airplane to right it. Turned out the angle of incidence was off on one wing."

Discovery developer, the late William (Bill) Shaw, then in his early 80s, and Hibler are somewhere on the way to Oshkosh in 1991. The Discovery was Shaw's dream of what the perfect airplane should be.

Compounding the flight-control issue was the use of marine-style Teleflex cables to operate the control surfaces, which had a bit too much slop for aviation applications. Besides the imprecise control feel overall, the elevator was prone to develop flutter at faster

Photos: Courtesy Earl Hibler

cruise speeds. "It was a constant battle," says Hibler, "fixing this or fixing that to get the thing flying."

Eventually, all of the major outstanding problems were identified and corrected, and it looked like making the Oshkosh deadline might actually happen. "I was making short hops with it," Hibler recalls, "and sneaking up on airspeeds. Basically, it was let's go find out what it can and can't do—there was no formal flight-test program for it. I had engine temperature issues, oil pressure issues, and since the engine came out of a salvage yard, it didn't have fresh magnetos on it. It didn't have a fresh carburetor—it didn't have any of that stuff that I insist on now."

The Sound of Silence

Just before Oshkosh departure day rolled around, Hibler took the Discovery aloft again just to be sure that everything was working as advertised. It was during this particular flight that Hibler learned a few more lessons about test flying, especially in the arena of engine accessory integrity.

"I'm up flying it one afternoon over Salinas," Hibler recalls, "and the marine layer's coming in. I'm thinking that I'd better get back down. Right about that time the engine quits, and I'm at 5500 feet. So I'm gliding around for a bit, trying to get it started again, and it won't come back to life. I trade energy for altitude, stop the prop and head for the Salinas Airport. By now, the marine layer's completely closed in, so I look at Watsonville, and it seems doable.

"I glide into Watsonville, and end up making a short approach on the north-south runway. When the wheels touched down at the end of the runway, there wasn't much energy left," Hibler continues. "Not only did I end up buying two new mags and installing them in Watsonville, but I ended up adding two new scoops to keep them cool as well. After that flight, it was off to Oshkosh."

Getting Acquainted, Cross-Country

With Hibler and Shaw aboard, plus baggage for the duration and tools, the bare-bones Discovery was pretty much at design gross weight for its inaugural trip to the convention. But it was here that the basic airframe design showed its stuff, which wasn't at all lost on its test pilot. "It really made a great glider, with the same wing area as Martin Hollmann's Stallion," says Hibler. "The cockpit view is just awesome, with somewhere near 200° visibility. It's kind of strange at first to look around without seeing wings around you, other than the short little canard in front. You have to lean forward to see the leading edges of the main wing behind you.

"And it's comfortable," Hibler recalls. "It's kind of loud for a pusher, but it's also relatively fast. It would easily go over 200 mph if you pushed it up there, but since we had this little fluttery, oscillation thing that took me awhile to figure out, we didn't plan on cruising too fast."

Earl Hibler perches on the fuselage while chasing yet another engine malady. He now confirms that engine accessories with unknown histories should not be trusted for long, or even short flights.

Climbing out of Salinas for the first leg of the flight to Oshkosh, it didn't take too long for the first gremlin to rear its ugly little head. "We were headed toward our first stop in Reno, Nevada, and the first thing that happens is that the airspeed indicator wound down and went away," Hibler remembers. "Oh, well. It wasn't the first time, so I just kept on flying by the seat of my pants. The loran navigation unit had quit working, but the transponder and communications radio worked OK along with the oil pressure and temperature gauges. So we put it down at Cannon and spent the night there."

Bright and early the next morning, Hibler and Shaw launched toward the next stop at Winnemucca, Nevada. With 30 gallons of fuel capacity and burning roughly 10 gph, this leg should have burned about 14 gallons at the very most, so crew confidence was running high. "We topped off in Winnemucca," Hibler recalls, "and I poured a bunch

On the ground in Yankton, South Dakota. Just a few flight hours from Oshkosh, the Discovery not only lost its engine oil but flattened the nose tire as well. A case of stage fright, maybe?

of Mobil 1 and Slick 50 in to keep the engine cooler. This turned out to save my a** later.

"We were running along," Hibler continues, "and we lose the alternator. Well, we still had battery power, and since half of the radios didn't work anyway, we don't need 'em. The nose landing gear is mechanical, so we just shut everything down and proceed with dead reckoning. After landing at a few small airports along the way, we finally made it to Yankton, South Dakota. Now we're really feeling the rush to get to Oshkosh, so we pulled the battery out to charge overnight and headed for the hotel."

Oil, Oil Everywhere

After spending the night in Yankton, the crew reinstalled the freshly charged battery and launched toward Oshkosh, just a few more hours away. But the gremlins were freshly rested as well and soon got back to their devious tricks. "We took off out of there," Hibler says, "and we were 10 minutes out when the oil pressure started coming down. I had a little mirror out on the wing to check for people around the prop, so I wouldn't hit anybody, and I see all of this stuff slinging out of the engine. Oh, crap."

An immediate 180 was made back to Yankton, and Hibler declared an emergency. The fire truck rolled to meet the inbound airplane, and the oil pressure needle came to rest at the bottom left of the arc. "I didn't know if I was going to make the runway or not," Hibler recalls. "I reduced power but kept enough to keep flying, got it back to Yankton, and back on the ground."

Either on landing or taxiing to the ramp, the Discovery also picked up a flat front tire, so it was starting to look like not a good day to fly. "Now, we're not going to fly anywhere that day," Hibler remembers, "so I got to fixing the airplane. I rented a car to drive to a crop duster strip about 35 miles away to buy a tire and a tube. I found an automotive alternator belt in downtown Yankton, along with a V-8 freeze plug and some Loctite. What had happened was that the engine had burned the plug out of the end of the crankshaft, and it was pumping oil out into the spinner. After replacing the belt and the plug, and changing the tire and tube, we were ready to go again."

Not Out of the Woods Yet

After departing Yankton, the next fuel stop was Rochester, Minnesota. As Hibler's bladder demanded immediate attention after landing, he made a beeline for the FBO's bathroom while Shaw was left to refuel the airplane. "I should've checked it, but I didn't," Hibler admits. "We took off, and we're now flying the final legs to Green Bay, then Oshkosh, by gosh. So we're cruising along at 5500 feet, talking to Green Bay approach, and the fuel pressure starts going away. I turned to Bill and said 'You *did* fill it up with fuel, didn't you?'"

"I filled *my* side up," Shaw replied.

After advising Green Bay Approach of the latest predicament, and learning that the nearest airport was 12 miles and 12 o'clock, Hibler divided his attention between finding the strip, cleaning up the airplane and discussing the latest situation with his co-pilot. "I'm bitching at Bill for not filling the airplane up, and I just keep gliding the airplane while searching for the airport," Hibler recalls. "And all I'm seeing are trees and water. I'd already pulled it up and stopped the prop to stretch the glide; I have no airspeed indicator and nothing for navigation but the compass. Finally, Green Bay says it's 1 o'clock and 1 mile, and ask if I've got it in sight. And I said, 'Negative.'

"But I know if it's only 1 mile away, I've got enough altitude left to make it," Hibler continues. "Green Bay now says that I'm right over it, I've still got 600 feet, and I roll the airplane over and can see this little matchstick-looking runway underneath, deep in the trees. I grabbed my camera, wound it up and took pictures of the runway and the stopped prop. Bill is about to have a cow."

After lining up for the runway and advising Green Bay that the landing was assured, the nosegear was lowered for an uneventful landing and rollout. After climbing out of the airplane, the crew was immediately greeted by an airport neighbor and her three boys, who astutely surmised that they were on their way to Oshkosh and had run out of fuel. "Happens every year," she said.

After rustling up two 5-gallon gas cans and hitching a ride with the nice neighbor lady to acquire some fuel, the trip to Green Bay was completed. But not until the evil gremlins came up with

Can You Keep a Good Airplane Grounded?

The "Re" Discovery team of Layne Dewlen (left) and Kenny Farrell (right).

Innovative aircraft designs never seem to die (and stay dead), despite the difficulties that one or another manufacturing group may have in successfully bringing the airplane to market. The late Bill Shaw's original Discovery design is a case in point, as it has languished during the last few years while sold as the Freebird Xtreme. Frankly, it's not easy for any light airplane, certified or otherwise, to be an ongoing sales leader in such a fiercely competitive market.

Enter retired US Airways Captain Layne Dewlen, and A&P Kenny Farrell, who were both smitten with the design when they first beheld it at AirVenture 2004. Dewlen and Farrell have formed a new company called Aero Concepts to bring the design back to the kit market, rechristened with the original Discovery moniker. Dewlen will serve as company president, with Farrell as CEO, and their plans include offering several different versions of the airplane to reach a much broader market segment.

Powered with a Lycoming O-235 or similar powerplant, the Discovery should meet the criteria for Light Sport Aircraft. With an O-320 or O-360, the Discovery will perform much like Shaw's original prototype. Stretching the fuselage to four seats, retracting the maingear and using a small turbine for power, the Discovery is claimed to be capable of cruise speeds in the neighborhood of 300 knots. "Of course, this is all down the road a bit," says Dewlen. Given that the Discovery has the same large wing area as Martin Hollmann's six-seat Stallion, these very different Discovery versions don't seem far-fetched at all.

The new Discovery also retains the original composite construction philosophy, with a suitable reliance on carbon fiber wherever needed. "Everything is pretty much in halves," explains Dewlen. "The kit will arrive with the spar already done, ready for the skins." Before any kits can be shipped, however, the new management team has to finish setting up manufacturing at its new home base in Rock Hill, South Carolina, along with all that goes with selling and supporting any aircraft kit.

Given the Discovery's proven efficiency, excellent visibility and unconventional appearance, it's very likely that this kit will resonate with quite a few builders looking to build and fly something a bit different. Progress of the new Discovery from Aero Concepts can be tracked by contacting them at 352/362-1139 or visiting *www.aeroconceptsllc.com*. —*R. L.*

a final trick: The electric fuel pump died, leaving the sole, engine-driven mechanical pump in charge of fuel-pressure duties. Hibler remained philosophical: "I knew it was going to get refueled in Green Bay, and there were *lots* of parts available at Oshkosh. As it turned out, I was the second-to-last airplane to land that day before the field was closed for the night."

Success at Last

The Discovery flew in the showcase every day during the show and garnered a significant amount of interest. Afterward, the flight back to Salinas wasn't nearly as...uh...interesting, and there were no major mechanical problems. The failed airspeed indicator turned out to be caused by a melted plastic pitot line routed too close to the exhaust, and the other electrical issues were mostly due to inadequate oversight during construction.

It's a no-brainer now to see where the human failures were in this episode, given the luxury of 20/20 hindsight and the accumulated wisdom of subsequent years. Most of the problems came from a powerplant and its accessories, which were inadequately prepared for such a cross-country sojourn. Overlay the picture with a fine patina of "get-there-itis," the siren song of potential sales from a new design and a touch of fatigue, and this flight could've had a very different and serious outcome.

However, the ace in the hole during this true story is an astutely competent Reno race pilot and A&P, who is an expert in aircraft energy management and knows light aircraft systems inside and out. As most of us will never acquire such a finely honed level of stick-and-rudder aeronautical skills, we can compensate only by making absolutely sure that we've performed our due diligence when preparing our aircraft—and ourselves—before undertaking such flights.

"Every flight was a learning experience," says Hibler. "But it would've been nice if the lessons were spaced out a bit more." ✈

PART 3

A Sign of the Zodiac

With an airplane to build, everyone gets into the act.

BY RICK LINDSTROM

Gus Warren tackles one of the most labor-intensive parts of the fast-build kit, the rudder. You're actually expected to measure and mark holes, drill and rivet, and make a few small parts. Heresy!

When we last visited the Zenith build team at the FlyCorvair.com hangar at Massey Airpark in Edgewater, Florida, the first Zodiac 601 XL fast-build kit fuselage was on its gear and happily rolling around within two days of its arrival. The next items to be accomplished were to build the rudder and start assembling the wings. We started with the rudder, because this small project actually requires the most skill from a neophyte builder (me).

As those who have attended the Zenith rudder-building workshop can attest, building one is a great way to acquire the basic skills needed to construct an all-metal Zenith airplane kit. Unlike the completely assembled fuselage and horizontal stabilizer, the rudder requires the builder to do things the old-fashioned way—measuring and drilling rivet holes, manufacturing small L brackets and finally riveting the piece together. If you can successfully build the rudder, Zenith feels that you can probably manage to build the rest of the airplane, and I agree.

That's not to say the process doesn't require care, the ability to follow instructions and a bit of forethought. Before any hole is drilled or any piece is cut or trimmed, it's best to take a moment and absolutely confirm that the immediate task is indeed correct and conforms to plan. But the good news is that if a mistake is made, all of the rudder's components are pretty inexpensive to replace for the next try. You'll just have to find something else to do until the new piece arrives from Zenith. (No, I didn't mess something up and learn this firsthand.)

No Shortage of Manpower

Given the novelty of building the first fast-build 601 kit, there was a steady parade of visitors, all wanting to observe

When you order the suggested tool kit from Zenith, this is what arrives. All of the tools are of high quality, and are more than sufficient to build a number of airframes before wearing out.

One thing you should scare up on your own is a deburring tool like this one, used to knock off the metal shards from freshly drilled holes. A quick twist or two and your work is done.

the progress. Fortunately, the airframe kit didn't disappoint, and it evolved quickly into a finished piece. This was partially due to a surplus of extra "hangar gang" hands at that time, all itching to get involved and do something constructive. And not just any task, either, as everyone wanted a shot at using the really nifty pneumatic rivet puller that comes in the optional Zenith tool kit.

There's something really satisfying about blind (or "pulled") rivet construction. Once the air pressure has been set properly at the in-line valve at the air hose fitting, the riveter pulls rivets perfectly with a satisfying *shoomp*. Too little air pressure, and the rivet is left partially pulled, with the mandrel intact. Too much air pressure, and the process gets a bit more uncontrollable, frequently bouncing the riveter and leaving an ugly dent on the soft aluminum skin. But when it's done right, a line of rivets can be quickly pulled, and the human part of the rivet system comes away with a real sense of accomplishment. The kit, of course, is then that much closer to actually flying, so everyone and everything wins.

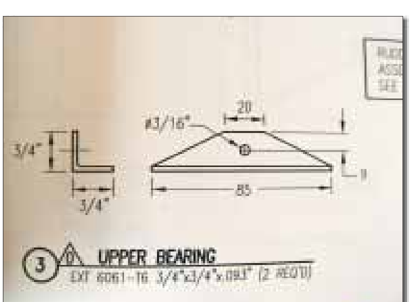
Tools for Metal Meddling

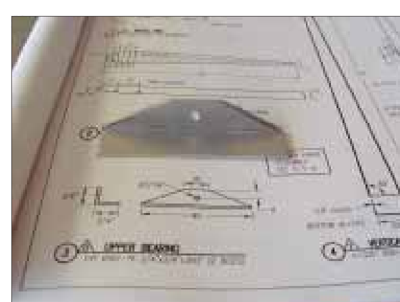
Before any rivets can be *shoomped*, some preparation is involved. Most of this comes down to drilling out and deburring rivet holes, and knocking the knife-sharp edges and corners off of those pieces that may come in contact with flesh. Other than the rudder parts, the balance of the Zodiac kit comes with pre-drilled pilot holes that make drilling to correct size for the rivet hard to get wrong. All parts have anti-corrosion chromate already applied to mating surfaces, and have labels that make absolute identification a snap. Major components that require solid rivets for strength, such as the wingspars and gear support brackets, come pre-riveted from the factory.

Deburring rivet holes and rounding the sharp edges can be done with an oversized drill bit on the holes and a small file on the edges, but it goes much faster with the right hand tools. The Fly-Corvair folks, being Zenith-building veterans, had a couple of deburring hand tools that made this process a breeze. A single twist of the hole deburrer (be sure to get both sides of the hole), and a few passes along the edges with the other deburring tool prepared the metal in less time than it takes to describe it.

The tool kit from Zenith also includes plenty of $^1/_8$-inch and $^5/_{32}$-inch Cleco fasteners, a good set of Cleco pliers, and left- and right-hand-cut metal shears for trimming the excess from the sheet aluminum parts. The Clecos are used to clamp together the pieces that are to be drilled and riveted, ensuring that all the holes will ultimately line up when it's time to pull the rivets. Zenith also includes a dozen or so each of #30 and #40 drill bits, and a high-quality air drill to shoot all those rivet holes through the parts. (Frankly, I wasn't expecting the tools to be of such high quality, and I would urge anyone ordering a Zenith kit to make sure to add the tools to the order list, even if you think you already have all the hand tools needed to build your kit.)

Another tool that comes in handy on a regular basis is a rotary air tool. When fitted with a rasp or grinding bit, it quickly trims away surplus cast and extruded metal from various items to





Some of the few parts that you're expected to make yourself are two sets of rudder hinges. All it takes is the blueprint, a couple of lengths of aluminum angle, and a bit of elbow grease driving a few hand tools. If you have a drill press, band saw and disk sander handy, the finished hinges appear in short order.

help produce shaped parts that closely match what's called for in the plans. With a small cut-off wheel, it's also the ideal way to trim away surplus plex from the canopy, or trim plastic or composite materials. Because this high-speed tool tends to fling shavings, filings or dust everywhere, appropriate eye protection and a dust mask are must-haves.

Shop Supplements

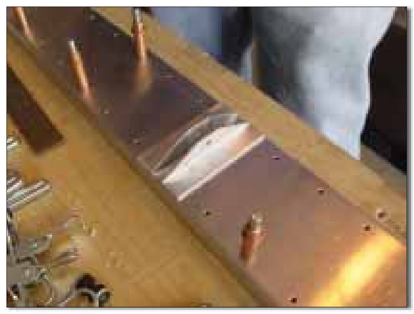
Building the rudder underscored the need for a few shop items that might come as a surprise. Some 3-foot lengths of 2x2 wood are perfect for keeping the rudder suspended above your work surface without having it rest on its Cleco fasteners. A few spring clamps are handy for keeping parts in rough alignment until a few Clecos can be installed. And duct tape comes to the rescue when trying to persuade a reluctant aluminum skin to assume a completely new shape around some ribs, until more permanent fasteners can be put to work.

Gus Warren and I were having a bit of a problem with the ribs in the rudder creeping out of alignment with the skin after the rivet holes were first drilled and deburred. Because the rudder internals were no longer easily accessible with the skin covering the whole assembly, we needed a way to scooch the ribs around slightly to allow the Clecos to be inserted. There was, however, a small gap at the ends of the rudder where something narrow and long might be inserted to do the job. This specially made tool turned out to be nothing more than a thin stick with a notch filed in the end, allowing it to grab the edge of a rib and finesse it back where the holes would align once more.

For me, this is the real fun of building. When confronted with a minor challenge, I love working up a plausible solution in my mind, and then scrounging around for the materials to put it to the test. Of course, when your solutions don't pan out, it does tend to get a bit frustrating. The good news here is that many other builders have taken identical paths before, and they aren't shy about sharing their experiences. If you go to the various online sites where Zenith builders congregate and toss out a question, you'll most likely find a fast answer, sometimes in mere minutes. If you're lucky, you might even start a spirited debate centered on which individual has invented the best solution. Entertaining *and* enlightening.

Making the freshly sheared aluminum sheets a lot safer to handle, Warren uses a different deburring tool to dull the knife-sharp edges prior to further airframe assembly.

Warren says that he found this particular tool at a garage sale. Although it's well over 50 years old, it was one of the most used hand tools in building the factory-fresh 601 XL kit.



Building the rudder begins with drilling out the needed holes in the rear spar, attaching the hinges and ribs, and finishing with the skin and end caps. Start to finish, we spent a full day on it .

Completing the rudder in the fast-build kit is identical to what's taught at the Zenith rudder workshops. Because all operations (measuring, marking, drilling, deburring, trimming and riveting) are employed in the rudder build, overall kit progress seemed to slow a bit.

The copper-colored Cleco fasteners are used for the $^1/_8$-inch rivet holes, and sighting down the line of Clecos is a great way to see if your measuring, marking and drilling skills are straight and true.

The black Clecos are for the larger $^5/_{32}$-inch holes, which accept both slightly larger blind rivets or a small machine bolts. The Clecos hold two pieces precisely in place while additional holes are drilled.

The Wing Thing

Even with all of the measuring, marking and drilling, the rudder took roughly a day to build. Being a relatively small piece, it was a bit of a tag-team effort, occasionally handing off the riveter so everyone got their own measure of riveting in. When finished, we spent a few minutes admiring the results of our handiwork, and then rustled up a couple of padded sawhorses to start on the wings.

Although significantly larger than the rudder, each wing is no more difficult to build, due to the prep work already completed at the Zenith factory. The mainspars come assembled with solid rivets, all of the ribs have their flanges and lightening holes where they should be, pilot holes ensure that the skins will line up with the ribs, and chromate has been applied where the two surfaces meet.Building each wing comes down to riveting the nose and main ribs in place, and following up with the skins. It's hard to get it wrong by installing a rib upside down, as Zenith provides part identification labels with arrows that indicate proper rib-to-spar positioning. However, it's not a good idea to just park your brain during the process, as you need to think about any nav or strobe lighting that will adorn your wingtips, or landing/taxi lights that may end up in the leading edge before the wing is closed. (Removing skins to run wires after the fact is downright embarrassing.) Also, look ahead to installing and rigging the control system.

It's also important to pay attention to the riveting plan at this point, and not put in every single wing rivet you may think is necessary while you're rhythmically riveting along. Because the fuel tanks are installed forward of the spar after the rest of the wing is complete, there are lines of rivets in this area that won't be pulled until after the tanks are positioned and secured with strips of cork material. But if you do need to drill out a few rivets, it's no big deal. One of the benefits of blind rivets is that they are easily removed with a few twists of a slightly oversized drill bit. Care should be taken, however, not to enlarge the rivet hole by being overly aggressive and letting the bit eat past removing the rivet head.

You'll also want to consider the aileron hinges. The 601 is designed without them, letting the top wingskin provide the up and down flexing between the wing and the aileron. It's elegant in a way: a smooth top skin from the spar

all the way back to the aileron's trailing edge, simple and maintenance free. The factory has done extensive testing to ensure that it's safe and will provide gazillions of up and down cycles before any sort of fatigue becomes a concern.

Being the suspicious curmudgeon that I am, however, I opted to go with a traditional style piano hinge on each aileron. Warren, who has flown extensively in 601s with both styles of aileron deflection, reports that low-speed aileron response was a bit better with the typical hinge setup, so I traded the elegance and simplicity of the single top skin for lighter aileron control forces in the flare.

Wing Wrap

The wings are big enough to allow two people to work on building them simultaneously, so the work went quickly. How you divide the tasks is up to you—sometimes the most efficiency was obtained by one person drilling and deburring, while the other worked on the control surface linkages. Sometimes one person set the rivets in the holes, while the other pulled them. Either way, it is always good to have someone nearby to double-check your progress, and ensure that nothing is forgotten or overlooked.

With two people making a modest but steady amount of effort, the first wing was completed (other than installing the fuel tank) in a single day. The second wing was also completed in a day, underscoring just how much time can be saved with Zenith's quickbuild option. In less than five working days, the fuselage was resting comfortably on the tricycle gear, and both wings and the rudder were built. I actually started feeling a bit guilty, knowing full well how long most builders spend constructing their airplanes from the regular kit, or from plans only. Of course, a quickbuild kit won't streamline your avionics or engine installation, but it was already apparent how this option can greatly reduce the time spent on the total project.

Zenith also provides a wide variety of clamps with its kits, which are invaluable in holding together pieces before any holes are drilled. Here, Warren is using one to check the initial fit of one of the hinges.

Parallel Efforts

Having an airplane appear on the hangar floor shortly after the crate arrived at the FlyCorvair hangar had some other benefits not initially anticipated. It served as an unavoidable prompt to get the firewall-forward package completed as soon as possible. Nobody involved with the other requirements of this project wanted to be the cause of an indeterminate delay that kept the

Before anything is finally riveted, everything should be "dry assembled" to make sure the rest of the pieces will line up properly. A permanent marker is invaluable in notating exactly where the parts should fit together.

601 from flying, so William Wynne's Corvair motor mount appeared in short order, and a gorgeous red engine block began the transformation into a new aircraft engine under the capable hands of engine builder Kevin Fahy.

Up in New Jersey, Craig Barnett from Scheme Designers was considering the shape and size of the trigear 601 to develop a suitable paint design that would work well with the square, angular shape of the fuselage. A cornucopia of different designs began to arrive via email, and the process of making a decision began to get complicated given the firehose output of Barnett's artistry.

I also had to start thinking about the panel layout. I wanted to leave as much panel space open as possible for experimentation later, so I decided to install the permanent radios and instrumentation in the center, leaving the sides open for tinkering.

Being tight with a buck (I'll admit it), I took advantage of any bargains available. The communications would be handled by a used King KY197 that I found on eBay, and the King KT76 transponder was surplus from a local avionics shop. I had previously talked with Ralph Krongold from I-K Technologies about one of his engine monitor systems that had a small 4x4-inch footprint, and he was willing to customize it to work with dual CHT and EGT readings from the Corvair installation, while providing fuel and oil pressure, oil temperature and tachometer functions.

I purchased the new G4 Lite from Blue Mountain Avionics to provide an attitude and heading reference system (AHRS) that also has GPS with terrain depictions as well as a virtual horizontal situation indicator (HSI). Miniature 1-inch "steam gauges" from UMA were selected to provide fuel, voltage and ampere indications in a minimum of panel real estate. It took a bit of research to find a good, inexpensive two-place intercom that also featured stereo music capability, but the new Sport 200 intercom from Sigtronics fit the bill perfectly.

This is where the project started getting interesting, as we began to receive the cockpit equipment, and the challenge was on to get it all working together properly. ✈

PART 3

Come Fly with Me—The eCFI

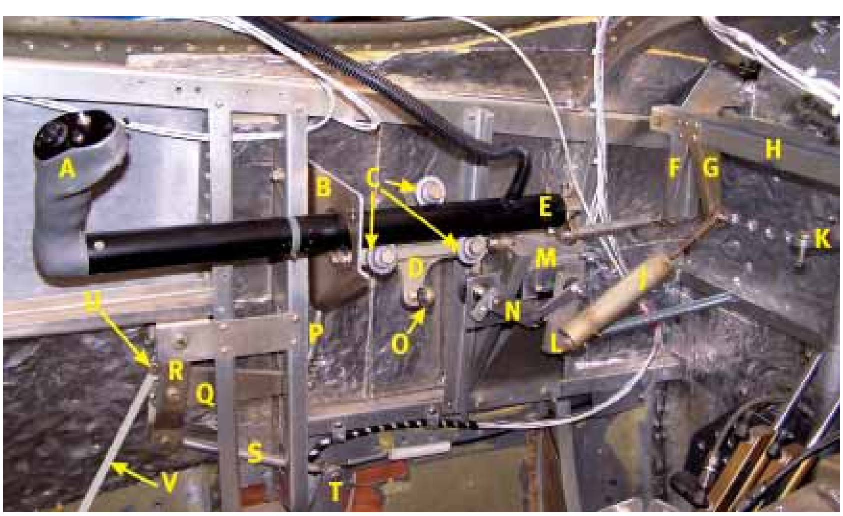
The University of Iowa's prototype pilot sensor system monitors multiple physiological parameters.

We offer some hardware ideas for those who may want to build their own systems.

BY BRIEN A. SEELEY M.D., PRESIDENT, CAFE FOUNDATION

This article presents some control, sensor and display hardware ideas to help builders begin planning their eCFI systems. Intermediate and advanced eCFIs should be capable of commanding the controls of the aircraft, much as would a real Certificated Flight Instructor (CFI). For this to happen, the control system must have actuators of modest size and power. The aircraft must be designed to have handling qualities whose control forces are not too stiff and are somewhat linear in force buildup.

When we rent a car, we pretty much expect the seat belt warning chime and that there will be a steering wheel, automatic transmission shift lever, speedometer, etc. Ideally, the personal air vehicle (PAV) controls, eCFI functions and displays will become similarly generic in both look and feel. Transitioning from one model of PAV to another would be much easier that way.



The Questair Venture side-stick control linkage. See the text for an explanation of each labeled part.

The Model

To expedite such development, Jim Griswold, designer of the Questair Venture, and Dave Anders, CAFE Triaviathon Champion and Venture builder, have kindly provided images of the Venture's control system to serve as a suitable model for an eCFI. You can watch its operation on a web video at *http://cafefoundation.org/v2/video/questair_test.html*. The photo shows the key components. Besides being a side-stick control, the Venture's design includes provisions for use of trim spring "cartridges" and an interlink for flaperon function. Both of these are valuable features for PAVs to be able to achieve the desired generic control feel.

The Venture's side-stick operation was designed to emulate that of the F-16, that is, by having minimal translational movement and relying more on the pilot modulating control by forces detected as "feel" and skin pressure. This design

NASA's Naturalistic Flight Deck uses this fly-by-wire side-stick control with Stirling Dynamics servo motors and built-in strain gauge sensors.

also seeks to minimize friction and thereby give designers the ability to tailor the breakout forces and their harmony by using spring cartridges (item J in the photo).

How it works: The black tube (E) pushes on F and G to rotate H, the torque tube, which moves another arm (not shown) up and down to move the elevator. The left-right tiller bar for the rudders is K. Item N is a stiffener brace that supports the trim position indicator's stub shaft just aft of the motor shaft (M), which houses the electric trim motor, and J is the elevator trim spring cartridge. The three items labeled C are tapered rollers that fit inside thin slots cut in the black tube (E), and allow fore-aft stick movement for elevator control. Items P, Q, R and S allow T, the flap actuator, to bias the position of the aileron pushrod (V), which attaches to the small bolt (U) on the bellcrank just aft of pivot R. Pushrod V was PhotoShopped into the picture. It provides the linkage to achieve flaperon action when flaps are down.

Ailerons move when the captive tube (E) rotates casting D about the longitudinal axis of the fuselage. Item B is the instrument panel bulkhead. Item O attaches to a transverse push-pull tube that is behind the instrument panel (item W in the second photo); W

eCFI Collaborators

The web site at www.landings.com/_landings/pages/avionics.html contains a comprehensive list of resources, but here are a few to get you started.

Jim Hauser's helpful site
www.aerospectra.com
303/499-2584

Dylan Schmorrows at ONR Navy
email: SchmorD@ONR.Navy.Mil
703/696-4259

Tom Dollmeyer from "Open EFIS"
email: Tom@Dollmeyer.com
812/350-2701

John Retelle at DARPA
email: jretelle@potomacinstitute.org
571/218-4595

Manufacturers and Other Contacts

Advanced Flight Systems
www.Advanced-Flight-Systems.com
503/263-0037

Avionics Hangar
www.avionicshangar.com
888/833-5487

Blue Mountain Avionics
www.bluemountainavionics.com
423/496-3510

Comant Antennas
www.comant.com
714/870-2420

Crossbow Technology
www.xbow.com
408/965-3300

Dynon Avionics
www.dynonavionics.com
425/402-0433

Electronics International
www.Buy-Ei.com
877/318-6060
email: Support@Buy-Ei.com

Garmin International
www.garmin.com
800/800-1020
A good story on the $8000 ADS-B unit from Garmin can be found at www.garmin.com/products/gdl90/

Grand Rapids Technologies
www.grtavionics.com
616/245-7700

Icom America
www.icomamerica.com/
425/454-8155

I-K Technologies
www.i-ktechnologies.com
818/302-0606
email: techsup@i-ktechnologies.com

JP Instruments
www.jpinstruments.com
800/345-4574

Maemo.org
https://garage.maemo.org/projects/katix-efis/

Microsoft
www.microsoft.com
800/642-7676
email: ronm@microsoft.com

OP Technologies
www.optechnologies.com
503/690-0800

PC Avionics
www.mountainscope.com/autopilot.jsp
Can connect to many low-cost autopilots using NMEA GPS standard

PC Flight Systems
www.pcflightsystems.com
email: info@pcflightsystems.com

Porcine Associates
www.porcine.com/gps/sc/sc_frameset.html

The Ray Allen Company
www.rayallencompany.com
760/599-4720

Sigtronics
www.sigtronics.com/air
909/305-9399
email: tech@sigtronics.com

Trio Avionics
www.trioavionics.com
Low-cost autopilot with NMEA GPS standard
619/448-4619

TruTrak Flight Systems
www.trutrakflightsystems.com
866/878-8725

University of Iowa Operators Performance Lab (Tom Schnell)
www.mie.engineering.uiowa.edu/Research%20Presentations/Tom%20Schnell%20Research.pdf

University of Iowa Pilot-Avionics Interface Engineering Study
www.news-releases.uiowa.edu/2007/February/020507pilot-avionics.html

Vision Microsystems
www.visionmicrosystems.com
360/714-8203

Vista Nav
www.VistaNav.com
866/627-1671

Pulse Oximetry

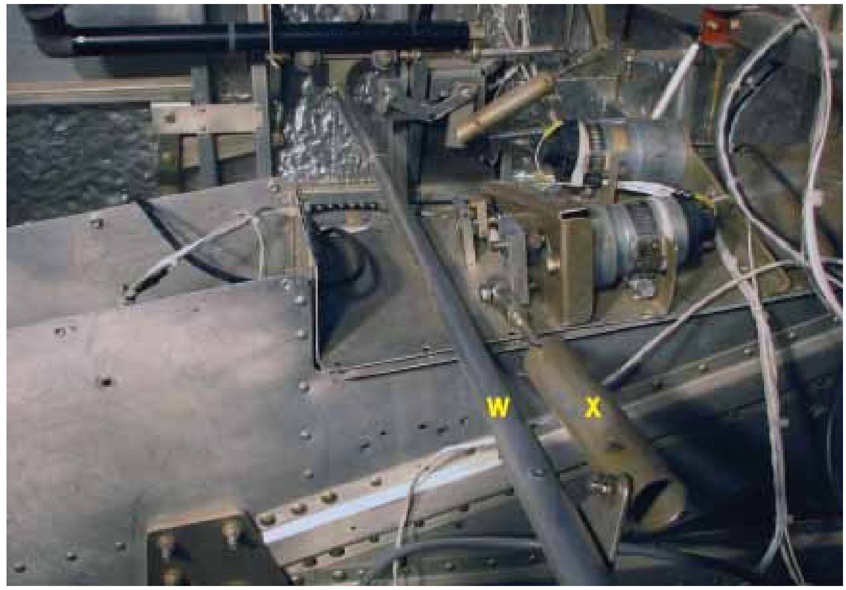
Simple, unobtrusive pulse oximeter sensors are available and could be used to monitor the pilot while providing a signal out to the eCFI system. Check these sites for more information.

FlightStat Oximeter
www.flightstat.nonin.com/

Nonin PureLight Sp02 Sensors
www.nonin.com/products.asp?ID=22&sec=1&sub=7

Nonin OEMIII Pulse Oximetry Module
www.nonin.com/productsasp?ID=26&sec=2&sub=9

Photos: Brien Seeley and Courtesy Tom Schnell (University of Iowa)



The Questair Venture control linkage illustrates the spring cartridge for roll trim.

attaches to the tunable roll-trim spring cartridge (X) and cross-links pilot and co-pilot stick movements for roll control. In the Venture, once the control linkages leave the forward cabin, both aileron and elevator are operated by cables and pulleys.

The spring cartridges for both the elevator and aileron trim contain two captive compression springs separated by a thick washer (piston) welded to the movable center shaft. The stiffness of both of these springs can be changed to alter the feel of push or pull, respectively. The web video illustrates this operation.

For advanced eCFI purposes, the linkages described above would need to be connected to a servo/positioning motor and strain gauge sensors. The motor would be capable of applying enough force to fly the aircraft on its own. It would use information obtained from the strain gauge sensors on the control pushrods to keep abreast of how much force was being used. How to apply these pieces of hardware is beyond the scope of this article, but strain gauges are small devices that can be bonded directly onto the metal pushrods. Ideally, the motors and strain gauges would be mounted in accessible/serviceable locations along the sidewall of the fuselage.

Other Essential Hardware

NASA's Langley Research Center has developed a sophisticated eCFI system called the Naturalistic Flight Deck (NFD). Ken Goodrich, a principal leader there, was kind enough to supply the images showing the fly-by-wire side stick-control and its underpinnings. The high quality servo/positioning motors shown in the photo are made by Stirling Dynamics of the U.K. (*http://www.stirling-dynamics.com*), where an enthusiastic contact is Stephen Judd (*sjudd@stirling-dynamics.com*).

Tom Schnell's group at the University of Iowa is developing what they call the Synthetic Flight Bag or SFB. Their work has expanded from being a low-cost synthetic vision system toward being a full-on eCFI that uses elaborate sensors to evaluate pilot physiological state. The prototype system will evaluate dense array electroencephalogram (EEG), electrocardiogram (EKG), electromyogram (EMG), facial feature points, facial temperature changes, eye movements, respiration frequency and amplitude. (See the photograph of the prototype's sensor-equipped pilot.) The SFB's display system is designed to be added to conventional instrument panels and consists of the hardware shown in the photos.

I hope that this series of three articles about the eCFI concept will stimulate kit-aircraft builders to begin making their own versions of an eCFI. Toward that end, a list of contacts in this field is included. ✈

CORRECTION

The statistic about CFI accident rates in Part 1 of this series was based on the number of fatal accidents per student pilot compared to the number of fatal accidents per ATP (airline pilot) from the NTSB 2001 report. However, that analysis does not account for the flight hours spent, nor the difficulty of the flying conditions. Consequently, rather than saying that student pilot flights with human CFIs aboard have a lower fatal accident rate than even air carriers, it is more accurate to say that student pilot flights with human CFIs aboard have about one-third as many fatal accidents as occur in personal and business flying. The 2006 Nall Report from AOPA likewise shows a dramatic improvement in GA safety with CFIs aboard.

—B.S.

Build Your Skills

If the mold you're working on is small, it can move all over the table if not secured. A bit of thin plywood makes a great base.

Ordinary packing tape is great for holding the mold to its base. Just remember to stay outside the boundary of the finished part.

COMPOSITES

In Part 4, we make parts from molds.

BY BOB FRITZ

"It ain't so much the things we don't know that get us into trouble, it's the things we know that just ain't so."—*Artemus Ward*

With that admonition in mind, and with an understanding that there's more than one way to do most anything in composites, let's dive back in. Last time we laid down gently curving fiberglass strips on the leading edge of an RV-10's windshield. This month we're going to get a bit more advanced. We'll make some parts from curved molds and then go to the opposite extreme, showing you a technique for making flat-side parts.

As you'll see, the previous advice about workspace preparation and proper tooling really comes into play. There's that word: play. With the right tools, it will be just that.

First, let's do some mold preparation. We're going to make some bits for a Falco. It's called an all-wood, plansbuilt aircraft, but let's face it, nothing is all-anything, so unless you're an over-the-top expert in wood, you're still going to have to do some work in composites. In this case, owner Mark Wainwright, a first-time builder, went to AirCrafters in Watsonville, California, for some assistance, and he was kind enough to allow us to document the process.

Those two shiny spots are valleys on each side of a ridge. Fill them with micro so that the shape doesn't transfer to this side of the finished part.

Note that this is not auto polish; it's specifically for mold release.

Where to Begin

Let's start with some fairings for the control rods on the ailerons. This is a small part, so it needs to be held in position, and a nice way to do that is to use packaging tape to hold it onto a thin piece of plywood.

It's obvious that the mold in the photo isn't the same as the one we just taped down, but it's a good example of the next step: keeping discontinuities off of the visible surface of the finished part. Look closely and you'll notice two shiny areas near the

Micro and epoxy. You won't need much, and it should be pretty stiff.

Here you can see the mold peeking out at the 6 o'clock position. Note that the threads of the fabric are also along that line, which is incorrect.

Smooth the micro on to the discontinuity and then don't worry about it. The epoxy will fill in the small holes.

As you can see, the valleys were not wide, but they would have been seen in the finished part.

apex. Those are valleys with a large ridge in between. The first step toward fixing this is to apply three coats of mold-release wax, letting each dry for at least 15 minutes before polishing it off.

Now whip up some micro with a bit of epoxy to about the consistency of cold peanut butter, and smear it onto the offending area, smoothing it with a wood depressor.

There's no need to get fancy. Let's step off to the side for a moment and think this through. This is a male mold, so when you see the mold, you're seeing the part. In this case, when the glass pops off the mold, the surface that does not touch the mold is the important one. But if I leave the discontinuity on the mold, the glass will follow the curve, generating an area to be fixed later. So I'll fill the valley with something that will stick to the glass but not to the mold. When the part comes off the mold, so does the micro. The result is that the discontinuity is still on your finished part, but only on the side not seen.

At this point, the astute reader will be thoughtfully musing: "Meathead! Why don't you just fix the mold?" The question was put to Dave Saylor, owner of AirCrafters. "The surface of the mold is finished as necessary," he said. "It can be nice and smooth or not. Smooth surfaces wax and release easier. High quantity production molds are usually smooth for ease of finishing and releasing. When the mold is hard to release, it gets dinged and scratched every time it's used, and has to be repaired in order to maintain the surface finish. It's like a woodsman sharpening his ax—the more time he spends sharpening, the less time he spends swinging."

Now, if this were a female mold, that is, a mold with a pocket to be filled, and had a similar discontinuity, we could do the same thing as long as the surface to be seen is on the side not touching the mold. Just keep in mind that the micro is going to stick to the glass, release from the mold and have the profile of the mold's discontinuity.

Now we've rotated the fabric 45° so that the thread lines don't cross the mold at right angles.

We also asked Saylor how to make a female mold. "A male mold is not the same as a plug," he explained. "A plug is used to make a female mold. For example, to build a cowl, first you might build a plug that simulates the cowl, then 'splash' a female mold over the plug. The plug will not usually look exactly like the cowl, but rather it will look sort of blank or plain. Details are added later."

Enter the Fabric

Having waxed the mold and filled the discontinuities, let's take a look at the fabric. The threads are at 90° to one another (warp and weave, remember?). To get the strength to be balanced we want to place the fabric onto the mold with as many threads as possible

Photos: Bob Fritz

crossing the long axis of the mold.

As much as you might like to use that rotary knife (assuming your teenager hasn't snagged it for cutting pizza), be aware that it works only on very smooth surfaces. If there are any grooves or bumps on the table surface, you won't get a 100% cut and the piece of material will simply unravel. Scissors are the ticket, but make sure to use the ones you bought for cutting glass, and if you get any wet epoxy on them, clean them immediately. In fact, go clean them anyway; they work best when you use the metal rather than an epoxy coating as the cutting edge.

Push and gently pull the fabric until it wraps down and stretches over the mold. This is an example of what we spoke of in the first article: drapeability. The process is much like last month in that you want to wet the fabric without displacing or over-stretching it. It's important that you see the fabric change from shiny, silver-white, to dark, wet and translucent. If it's not, add some epoxy.

Peel-ply: Priceless

Here comes our peel-ply, whose purpose is to chase out the excess epoxy and leave a surface finish with what a painter would call "tooth," or roughness that allows the next coating to adhere. Just keep in mind that peel-ply is not a structural component; you're going to remove it (we hope), so the fact that it won't conform to the shape is immaterial. A patchwork of separate pieces is fine. Just make sure to cover the entire surface.

On this mold you might try draping long, narrow strips first down the longest edges, followed by going diagonally over the glass. They stay in place better than 1-inch squares. Then just stipple it down with the brush, forcing the excess epoxy out through the peel-ply. Don't go nuts trying to remove it from the peel-ply; you can let it dry there.

Before we move on to the flat-side mold, let's take a time-out to look at an interesting comparison. These two parts are identical except that one weighs

These molds are about 10 inches long, 2.5 inches high and only $^3/_8$ inch thick. It's amazing how nicely the flat fabric will conform to that extreme shape.

Pushing the material to conform to the surface of the mold is easier than it seems. But you can take it only so far without it springing back. At some point it's best to continue the forming with a very wet brush.

Like we showed last month, wet the fabric with the epoxy, being careful not to displace the fabric.

Don't worry that the peel-ply is too stiff to go on in one piece; a patchwork works just fine.

Here you see the start of the peel-ply and also the orientation of the fabric.

Peel-ply is all finished. Because they're on a board, we can move the parts to a warm spot in the shop and have our bench clear for another project.

Other than the glossy sheen, these pieces don't look hugely different, but they are. The one on the left weighs double what the right one weighs.

Here you can see why there is such a weight differential even though they came off of the same mold.

Harold Bunyi's six years at the Lancair factory shows when he emphasizes scraping the table to get the old epoxy off. He uses an ordinary wood chisel for the job.

almost twice as much as the other. "Why is that?" you ask. The thick one weighs 49.5 grams, and the thin one weighs exactly 25 grams. The only difference is that the lightweight one had peel-ply treatment, and the heavy one did not.

Now we all know someone who was completely fanatical about the weight of his project during the building process and, after a couple of flights, started carrying an extra toolbox and a couple of quarts of oil in the plane. Or there's the guy who spends 300 hours cutting out lightening holes and weighing the scrap to make sure he has a really trim airplane. Only thing is, he had a couple of six-packs while doing it! The point is that if you squeeze out the excess epoxy, you'll have room for the oil or the six-pack. But there is also the option of addressing the system weight. Both you and the airplane will fly better.

Working with Flat-Side Molds

Anyway, speaking of making things flatter, let's look at a different technique that works for flat-side molds. The operative word here is flat, so the first thing to do is to get the workbench clear of hardened epoxy drips and other blips. How flat? Follow through on this and it'll become apparent.

In this technique, we're going to eliminate the excess epoxy even before we get to the mold. Start by measuring the flat area of the mold. Well, OK, it's not flat. It curves, but not simultaneously in multiple planes, so simply measure one side, over the top and down the other side. Add an inch, and that's the length of the fabric. For the width, measure the length of one side, plus one end, and then add an inch.

This happens to be a component that's going to take a lot of load, so we'll need to cut two pieces of fabric, plus two sheets of plastic wrap 1 inch larger than the fabric. When cutting the fabric, remember to cut on a diagonal relative to the threads. If you can find a diagonal on the plastic wrap, let me know.

Next we'll lay down one sheet of the plastic wrap on our smooth workbench, and center a single sheet of fabric on it. Although it's tempting to pour the epoxy, you should brush it on, smoothing and spreading it over the entire surface. Now look for the thin threads in the fabric and orient the second cloth with the thin thread at 90° to those of the first cloth, then center the second cloth over the first. If the cloth isn't square, you'll go nuts trying to do this by rotating the second cloth—ain't gonna happen, Bunky. Simply flip the second cloth over, and there you go. You're probably getting fuzzy-headed about now,

Here's how the sandwich begins. Not the eating kind, though you'll use plastic wrap and a pizza wheel.

The sandwich is opened. It's two layers of cloth placed 90° to one another between two sheets of plastic wrap.

The sides are flat, and, ignoring the saddle at which Mark Wainwright is pointing, the curve over the top means a rectangular shape of material will cover it all.

Look closely and you'll see that the fabric has thick threads and, at 90°, thin ones.

but hang in there. This takes longer to explain than to do, and it's obvious once you go through it the first time.

As before, spread a bit of epoxy onto the second cloth; it won't take much because the cloth below is already wet. Lay the second plastic wrap in place and, using a roller but not pressing excessively hard, squeeze the epoxy into the fabric and out beyond the plastic wrap. You could also put a thin layer of epoxy on top of this sandwich and then, using a squeegee, clean that epoxy off. That last coat of epoxy is a lubricant to keep from pulling the wrap.

Neat and Trim

Next, you finally get to use the circular razor. Trim all around, cutting through the bottom layer of plastic wrap. Right now this sandwich looks like something you might put on your lower back for sore muscles. Word of advice, though—don't. Instead, carry it over to the mold and set it aside while you give the mold a thin coat of epoxy. Now peel off one layer of the plastic wrap, and drape the exposed cloth over the mold. You can center it, and work it around a bit, but eventually you'll want to peel off that second plastic wrap. From here on you only need to fold the ends around and then, using your brush, push the whole thing into shape over the mold.

Add some peel-ply, work out the excess epoxy (there won't be much because of the sandwich method), and let the whole thing sit for a couple of days in a warm area. How long to cure depends partly on how you mixed your epoxy, but more so on the temperature. If your shop is around 50° F, as it was when we did this, you'll need to let it sit for 24 hours before taking a small part from a simple mold, and three days for a full cure. As I said, it's easier than you first thought and takes longer to describe than to do.

For more information about AirCrafters builder assistance, call 831/722-9141, or visit www.aircraftersllc.com. A direct link can be found at www.kitplanes.com.

Above: John Conard is building his plane in the SteinAir shop, and he's chosen an XCOM radio.

PART 5

EFISes and GPSes get all the play, but you'll want a strong communications suite and backup navigation.

BY STEIN BRUCH

ALL ABOUT AVIONICS

While the normal "radio stack" used to be a pair of nav/coms—two functions in one radio, an idea that dates to Narco Superhomer days—plus a transponder, ADF (automatic direction finder) and perhaps a DME (distance measuring equipment), the world is different today. Central to the stack now is at least one GPS for navigation, often packaged with either a com radio, or a com and a nav. The Garmin GNS 430 and 530 are the key boxes in this category, but they don't come cheap.

Still the Need

Yet even a modern cockpit has use for more traditional nav/com radios. In fact, we see this often in airplanes that will be operated occasionally under IFR, where a VFR GPS often does the deed just fine, but a conventional VHF nav radio is needed to receive VORs and ILSes. If you fly a lot of IFR, you'll find that a large majority of controlled flights are on airways between VORs—points that can legally be defined by a regular old nav radio or an IFR-qualified GPS but not by a VFR-only box. Many pilots find having a VOR/ILS receiver onboard a good backstop—and their legal out—even while principally navigating with the GPS. Hey, it happens.

Moreover, many pilots find it operationally useful to have a second com radio—to pick up the airport ATIS while still talking to approach, for example—as well as comforting in case the primary goes dead.

The modern "light IFR" panel of today often includes a nav/com, like this Garmin SL30, a VFR GPS and, when entertainment is important, a fully featured audio panel, like this PS Engineering PMA8000B.

From Germany with Love

Germany's Becker Avionics has made a name for itself as a manufacturer of high quality, durable and extremely reliable radios.

AR4201. The 4201 is the latest in the AR line of standalone radios that mount in a standard 2.25-inch mounting hole. Offering standard digital tuning and flip/flop, as well as 99 memory channels, this radio is small, lightweight and a popular choice in light sport aircraft and gliders, as well as many homebuilts. The Becker radios also interface with some EFISes. We've had good experiences with these radios and cannot find any faults with them.

Pros: Exquisitely built and reliable.
Cons: Somewhat pricey.
Price: $1350.

We Still Say Bendix/King

Having overtaken the lead from Narco some years ago, King—then Bendix/King and now part of Honeywell but wisely retaining the B/K branding—is now seeing a similar phenomenon happening to it (being overtaken by competition). While the company continues to produce the venerable and once wildly popular KX series of radios, their popularity is but a fraction of what it used to be. Word is that parent company Honeywell is working hard, internally, to return to its general aviation roots with modern products, but for now the choices are well-established models.

Photos: Stein Bruch and Courtesy the Manufacturers

Garmin's GNS480 was once the Apollo CNX 80. It contains internal nav and com radios as well as an IFR/WAAS-approved GPS for precision and non-precision approaches. The 480 can also channel a remote transponder.

Bendix/King KX125. This entry level (but capable) nav/com from Bendix/King is still a good value for those who don't need the high-end functionality of a full-blown ILS type box. With a built-in CDI (bar graph) display, the KX125 doesn't have glideslope capability built in, but does tune localizers. This radio does not easily interface with many available EFISes.

Pros: Good Bendix/King quality, reasonably compact package, doesn't require external nav head or resolver for VOR and LOC.

Cons: Must add external glideslope receiver, does not easily interface with modern EFISes, perilously close in price to the more fully featured SL30.

Price: $2600.

Bendix/King KX155 and 165. With many thousands of these radios installed, it's more than likely that you've flown behind one. The KX155 and 165 series of radios were the de facto standard for many years, but are since being surpassed by competition. While these radios don't have as many bells and whistles as the competitors, they are still a fine basic nav/com unit. Available with or without built-in glideslope receiver, this series of radios interfaces to very few available EFISes, but easily drives many external CDI/HSI instruments. The com portion offers basic flip/flop frequency management but no frequency storage beyond that. There are literally thousands of these radios in the field, and reliability seems excellent. That being said, they are somewhat larger, heavier, more difficult to install and less functional than the Garmin units.

Pros: Once the gold standard for reliability and durability; still excellent.

Cons: Basic feature set, more complex wiring, comparatively high price.

Price: $3000 - 4500.

KY96/196/97/197A. These stand-alone com radios from Bendix/King offer a variety of outputs and two different display/chassis mountings. The lower end 96A/97A are capable radios, but the higher end 196A/197A are a bit more attractive and offer a more standardized appearance—important if you have other Bendix/King gear in the airplane. The big differences are that the 196/7 series has a more powerful transmitter—10 to 13 watts against the 96A/97A's 5 to 7 watts—and a gas-discharge display; the cheaper coms have LCDs. You might also see B-suffix versions of these radios available; they are modestly face-lifted items brought out to improve the appearance of Cessna's new panels when production of the single-engine line resumed a decade ago.

Pros: Strong, basic radios; good service support.

Cons: Not a lot of bang for the buck, except in the Crown series.

Price: $1350 - $4500.

Resistance Is Futile

In a world where one manufacturer dominates—and, yes, that would be Garmin—it's interesting to note that three of its more advanced boxes were designed and originally built by another manufacturer—a company called II Morrow, which became UPSAT (for UPS Aviation Technologies, as in the package delivery company UPS) whose products were christened Apollo. The CNX-80 became the Garmin GNS 480 with changes, but the Apollo Slimline collection has survived in the form of the SL30 nav/com and the SL40 com.

Garmin SL30. The SL30 nav/com is arguably the best radio in this category, employing modern digital technologies and a host of features found nowhere else. This radio has a built-in glideslope receiver that makes hooking it up a breeze (no splitter required). The SL30 has the ability to display VOR radials on the screen via a small LCD bar-graph-type display as well as drive an external CDI for full ILS/VOR/LOC/GS display. The SL30 is also one of the few radios that will interface with most of the popular EFISes on the market via a simple RS-232 serial line, allowing you to see a CDI/HSI on your EFIS. It also includes a stuck-mic timeout, NOAA weather receive capability, multi-voltage input (10 to 40 volts, according to Garmin), and a built-in simple intercom. The SL30 (and the 40) can also accept com channeling from a Garmin 296, 396 or 496 through the serial connection; highlight a frequency, com or nav in the GPS's database, and it'll appear in the standby window.

Garmin SL40. This cousin to the SL30 is nearly as full featured, with

Icom's A200 is a fine, well-understood com radio, but don't expect a lot from the internal intercom.

memory storage, multi-voltage input and stuck-mic protection. It lacks the SL30's nav receiver. It's a strong performer for a standalone com.

Pros: Compact, good-performance boxes with a ton of features.

Cons: SL40 not as fully featured as the 30; some users say the knobs and buttons are too small and "delicate" for comfortable use in turbulence.

Price: $1500 - 3400.

The GNS series. The *GNS 430, 480* and *530* have become the industry leaders for installations in IFR-capable aircraft. The GNS series of radios is available in differing power outputs, but all of them offer fully functional conventional nav (VOR/LOC/ILS) capability along with full-feature com radios. You can opt to display some of the information on the screens, or drive an external CDI. The GNS series also couples nicely with most modern EFISes, allowing you to display your nav information on your EFIS. Additionally, they will couple nicely with some Experimental autopilots such as the TruTrak Sorcerer, allowing you to then fly coupled approaches. Currently, these boxes are the best all around "bang for your buck" when you look at everything they include. (We'll get into more detail on these units next month when we tackle panel-mount GPS options; they're included here because of their strong nav/com functionality.)

Pros: Tons of features, excellent integration with Experimental EFISes and autopilots. Huge dealer network and great factory support/warranties.

Cons: Higher priced than some competitors; radios are somewhat deep for certain sport planes.

Price: $8000 - 20,000.

Hearing from Icom

Icom America currently offers the IC-A200 in both TSO'd and non-TSO'd versions. (A new IC-A210 is in the wings, but we don't have a pile of info on it yet.) As a nicely capable com-only radio, this unit has become a solid choice for homebuilders looking for either a low-cost primary com or a secondary com. The Icom also offers a built-in intercom, but we (as well as many users) don't consider it very usable compared to the dedicated intercoms that are currently available. Icom also offers this radio in a base-station version, which is nice to have in your hangar or at an FBO for monitoring airport traffic.

Pros: Best bang for the buck when it comes to a second com; very supportive manufacturer.

Cons: Flat card connector, and internal "intercom" is almost useless.

Price: $725 - 900.

Com from Down Under

Microair VHF-760. The Microair VHF-760 was one of the first low-cost VHF coms available to the Experimental market. It is lightweight and draws very little power, and is attractively packaged to fit within a 2.25-inch standard mounting hole. These radios have been extremely popular in the glider and VFR light plane community due to their low power draw and small mounting dimensions. Our experience with these radios has been mixed. The mounting size is attractive, but overall reliability has historically been hit and miss. Additionally, we have not found the internal intercom to be nearly as functional or usable as a standalone intercom. These units are manufactured in Australia.

Pros: Small size and with many units installed. Internal intercom and other nice features. Mounts in standard 2.25-inch instrument hole.

Cons: Hit and miss reliability in our experience, but improving.

Price: $970.

A Famous Name from the Past

Once the standard in avionics, The Narco brand today doesn't hold the reputation the company once enjoyed. While it still offers several units in this category, it should be noted that installations in new homebuilts are but a fraction of what they once were.

Narco MK-12D+. The latest in a long line of popular MK-12 series radios, the D (for digital) nav/com is a functional piece of equipment. Offering the standard digital capability of the competitors, this radio is somewhat larger and heavier than the others. Available with or without glideslope receiver, this radio also doesn't interface well with modern EFISes, but can drive external CDIs and indicators. I've had a MK-12D+ with CDI installed in my RV-6 for years and it's a great radio, but with better options available from the competitors I'd likely not install it today.

Bendix/King's latest KX155 enjoys a new faceplate, an internal timer, CDI and channel memory, but has the same basic operating architecture as the older, more familiar 155s. Buy carefully: There are different voltages.

Pros: Lots of units installed, decent reliability and available on the used market for low prices.

Cons: Large size, lack of functionality when compared to competition and factory support. Parts can be expensive.

Price: $3000 - 4000.

NAV-122D/GPS. As one of the only manufacturers to offer a standalone NAV radio, this modern version of the original NAV-12 standalone indicator is a nice (but relatively expensive) unit. It's a good addition for those looking to add nav capability to their existing plane. The basic 122D is a full-feature nav receiver complete with VOR/LOC/ILS capability, and with the GPS option it becomes a legal CDI for installed GPSes. It's unfortunate that the price point is so high, because they really are nice units. However, unless the price comes down a bunch, we can't see these units as being overly popular in today's homebuilts.

Pros: Good features in a small package.

Cons: High price, no interface to external CDIs or EFISes.

Price: $3350 - 3900.

Val as in Value?

INS-422. Somewhat of an underdog in this category, Val Avionics offers a nicely packaged "all in one box" nav receiver. It includes VOR/LOC/ILS functions plus three-light marker beacon receiver. The INS-422 uses a horizontal and vertical digital LED representation of a CDI. This is a nicely priced and functional box that doesn't get quite the play it deserves.

Pros: Small, affordable standalone nav unit with indicator.

Cons: Relatively unknown in the marketplace, small network of dealers.

Price: $1995.

What, Another Aussie?

XCOM-760. XCOM Avionics offers another Australian-made com radio (with similar roots to Microair), and it also mounts in a standard 2.25-inch hole. This small, lightweight and highly functional radio includes the standard digital flip/flop and tuning, as well as some unique capabilities. The XCOM-760 allows you to monitor both your standby and active frequencies, NOAA weather stations, and has a built-in VOX intercom (that really does work nicely as a true intercom) along with the ability to listen to VOR frequencies (for AWOS, etc.). XCOM is also one of the only manufacturers to offer a remote mount unit with a small control head.

Pros: Lightest weight and most feature packed unit. Mounts in standard 2.25-inch hole. The company also offers a "remote" head version of the 760.

Cons: New(ish) to the marketplace.

Price: $1275.

Summing Up, Some Options

Not all nav and com radios need to be permanently mounted. In fact, it's become increasingly popular for lighter Experimentals to use a single hard-mounted com radio and a handheld backup. For anywhere from $200 to $400, you can

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Icom America
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Narco Avionics
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www.narcoavionics.com

Val Avionics
800/255-1511
www.valavionics.com

XCOM Avionics
+61 7 5568 7770
www.xcomavionics.com

have a full 760-channel radio that's independent of the ship's power, portable enough to haul around the hangar so you can listen to airline pilots committing gaffes with air-traffic control—that's a joke, Captain!—and nicely featured. To make such a solution work, you need three things. One, an external antenna on the airplane is a must. The rubber duckie antenna just doesn't cut it—it works close in but may not when you need it most. Two, you need a headset interface. Most handhelds are offered with these as options or as part of special bundles. Be sure you get one. Holding the radio to your ear while managing an emergency situation isn't the least bit fun. Three, work out a good power strategy. For radios with rechargeable batteries, come up with a system that keeps the battery charged and, if it's a nickel-cadmium battery, properly cycled to ensure long life. Better yet, buy the optional battery pack that holds alkaline batteries; they are resistant to the effects of sitting around waiting for you to need them.

Overall, homebuilders right now just don't have a huge variety of options for panel-mount nav/coms. To be quite blunt, Garmin is walking away with the panel-mount nav/com market and leaving everyone else in the dust. Intentionally or not, both Narco and Bendix/King have seen their market share greatly eroded with lack of functionally comparable units. We like Garmin because their stuff is highly functional, easy to install, easy to service, and Garmin really listens to pilots when adding functionality to its units. With that being said, companies like XCOM, Icom and Becker are all still doing a thriving business, and we like their products as well.

Join us next month when we dive into the fascinating and constantly evolving GPS market.

If you have specific questions for author Stein Bruch, or have certain projects you'd like us to cover, email us at editorial@kitplanes.com with "About Avionics" in the subject line. ✈

Manufacturer	Model	Nav	Com	Size (H x W x D) inches	Weight (pounds)	Output (watts)	Standby / Memory Channels	Intercom
Becker								
	AR-4201		X	2.3 x 2.3 x 7.5	1.5	5 - 7	99	Internal, Standard
Bendix/King								
	KX125	X	X	6.25 x 2 x 10.16	3.9	5 - 7	No	No
	KX155/165	X	X	6.25 x 2 x 10.16	4	10	No	No
	KLX135A		X	6.25 x 2 x 11.4	4.4	5	Direct from GPS	No
Garmin								
	SL40		X	1.3 x 6.25 x 10.5	2	8	16	Yes*
	SL30	X	X	1.3 x 6.25 x 10.5	3.3	8	16	Yes*
	GNS 430W	X	X	2.65 x 6.25 x 11	6.6	10 - 16	Direct from GPS	No
	GNS 480	X	X	3.25 x 6.25 x 11.8	5.8	8	Direct from GPS	No
	GaNS 530W	X	X	4.6 x 6.25 x 11	9.5	10 - 16	Direct from GPS	No
	GNC 250XL		X	2 x 6.25 x 5.8	3.2	5	Direct from GPS	No
	GNC 300XL		X	2 x 6.25 x 5.8	3.2	5	Direct from GPS	No
Icom								
	IC-A200		X	1.3 x 6.3 x 10.7	2.4	7	9	Yes*
Microair								
	VHF-760		X	2.25 x 2.25 x 5.3	1.1	4.5	25	Yes
Narco								
	MD-12D+/R	X	X	2.5 x 6.25 x 11	5	8	10	No
	NAV-122D	X		3.25 x 3.25 x 10.85	2.5		No	No
Val								
	VHF-760		X	1.4 x 6.25 x 12.5	3	8	No	No
	INS-422	X		3.32 x 3.45 x 10.8	3.2		No	No
XCOM								
	XCOM-760		X	2.4 x 2.4 x 5.8	0.9	6	99	Yes

* While these units are advertised to have an internal intercom, we strongly recommend a standalone intercom to be installed.

EFIS Integration +	TSO'd	Price	Notes
Yes	Yes	$1495	High quality, extremely reliable, intercom is decent. Mounts in standard 2.25-inch instrument hole.
No	Yes	$2600	Has built-in CDI for VOR/LOC.
No	Yes	$3000 - 4500	Thousands have been delivered, good standard radio. Price depends on voltage and glideslope converters.
No	Yes	$3100 - 3500	Price depends on GPS database. Old generation GPS screen, but usable.
Yes	Yes	$1600	One of the best com radios available on the market. Built-in intercom isn't as good as a standalone unit.
Yes	Yes	$3750	Hands down the market's best nav/com. Ability to listen/monitor standby frequencies is like having two radios.
Yes	Yes	$8000	This industry standard is now even better, being fully WAAS certified.
Yes	Yes	$9500	Definitely marketed to the IFR pilot, this capable box is certified for WAAS IFR, nav, com and GPS.
Yes	Yes	$15,800	The 530 is the largest and most capable of the GNS series.
No	Yes - VFR only	$3000	Nice GPS com, but not IFR-certified GPS.
Yes	Yes	$3000	Nearly the same as the 250XL, but with an IFR-certified GPS. (Price is for overhauled unit.)
No	Both	$725	Excellent low-priced com for either primary or secondary radio. Internal intercom not worth using!
No	No	$975	Lightweight radio fits in a standard 2.25-inch mounting hole. Intercom is OK.
No	Yes	$3050 - 4000	Mainly sold as an upgrade to older MK12s and Cessna radios, but works fine for homebuilts as well.
No	Yes	$3300 - 4000	Nice way to add VOR/ILS capability to an aircraft without major modification or wiring.
No	Yes	$675	Nice little radio for the money.
No	No	$1995	Standalone nav unit that is reasonably priced.
Yes	No	$1200	Nice intercom, ability to "listen" to VORs.

+ Check with your EFIS manufacturer for specifics. Not all radios will work with all EFISes.

Used Sparks

Does buying *pre-owned avionics* make sense?

BY LARRY ANGLISANO

To combat the sticker shock that comes when pricing new avionics, many builders consider used equipment. But does it make sense to drop money on used equipment, especially aging equipment that has been in service for 15-plus years? How does new equipment compare in price and utility? Let's have a look at what's out there, and see if you're money ahead or simply looking for trouble choosing this path.

Sounds Good…

You might not need a full rack of radios, and by this we mean dual nav/coms, ADF and DME—all systems that once made a traditional avionics stack. So a traditional audio switching panel might not be necessary. Why waste money on an old Bendix/King KMA20 or Collins AMR350 audio panel, for example? The audio quality provided by these units isn't that good. And why buy a panel that has audio capabilities for ADF, DME, telephone or marker beacon when you don't have these receivers?

New or used, we recommend something like PS Engineering's model PMA4000. It's a basic audio controller that can accommodate the switching of two com radios, two nav radios and has an integrated voice-activated intercom. It's available in a 2.25-inch instrument hole mounting configuration and a traditional intercom-style mount. When you install this or any intercom, use shielded wiring or you'll invite noise and frustration.

Garmin's GMA 340 is a common choice, as is the PMA8000 audio control panel from PS Engineering, but you'll likely not find great used bargains. They can handle unswitched warning and message inputs from engine monitoring systems and autopilots, so springing for a new unit may offer utility and room for growth. If entertainment input is a must-have, go with PS Engineering units because the company perfected the task of in-flight music with stereo input circuitry on most of its products.

If you plan to go with just a single radio, you may not need a switching panel. But if you plan to carry passengers, you should have an intercom, and the market is flooded with used models. You should be able to score a PS Engineering PM1000-series four-place intercom (which can be wired for two places). It has entertainment input capability and is voice activated, and it can be had for $150 or less used. Avoid old units like the David Clark Isocom and Sigtronics models that may have lived hard lives in rental aircraft.

Experienced Nav/coms

With a good nav/com system equipped with a glideslope receiver, you'll have reasonable utility for the occasional IFR trip. By good, we mean something that has 760 channels for communications and is synthesizer-controlled. Having glideslope capability could pay for itself in one flight.

Our top choice is Bendix/King's KX155, but it carries some caveats. All vintages of the KX155 can be prone to display failures—worn out gas discharge assemblies that cost more than $200 plus labor to replace. Display lenses damaged by the sun aren't cheap, either.

The KX155 and VOR/LOC converter-equipped KX165s (for driving

The evergreen Bendix/King KX155 is a nav/com stalwart. But beware there are many iterations, and those bright gas-discharge displays are prone to failure.

Garmin's GNS 430 is a wonderful box, and more are showing up used as owners upgrade to larger screens.

HSIs) are familiar to most seasoned technicians. These units are voltage specific, and a 28-volt variety won't do if your kit has a 14-volt electrical bus. Some units have glideslope boards; some don't. Buy a KX155 that is glideslope equipped, because adding the board later is pricey—about $1500. The difference between VOR/LOC-only and glideslope-equipped is about $500.

Analog KX155s will drive the KI209 (for glideslope) and the KI208 (VOR only) nav indicators. KX155s also drive the KI203 and KI204 rectilinear indicators. If any of them suffers a meter failure, consider them throwaways. On average, a clean KX155 with glideslope should sell for about $2500 plus the cost of an indicator—$600 or so for a KI209.

If you can find a deal on a used Garmin SL30 nav/com, it's a great choice because it's slim, has a completely digital architecture and allows monitoring of the standby com and nav frequencies for cross check. It can be wired for integral intercom. About $3000 is reasonable on a used one if it's been to the factory for updated mods. The indicator for the SL30 is the MD200, a high quality nav head made by Mid Continent Instruments (for Garmin). Expect to pay a grand for a used one.

The Other Players

How about Narco Avionics and the digital MK12D? These are good performing radios, but they are larger and heavier than most. We prefer the KX155 hands down. Collins VHF251 coms and VIR351 navs are tempting given their square design, but avoid them because of their age and declining support. The Terra TX760D and TN200D are com and nav units. You won't find many shops willing to work on them, however. Free Flight Systems in Texas will support some later Terra radios, but we strongly caution against choosing a full set given the lack of field support. As for Terra Avionics, it's long gone.

Standalone Com Radios

If you plan to fly VFR point to point via GPS, a standalone com radio might be all you need, skipping VOR. The used market is full of them—from mechanical analog Narco COM120s (avoid these) to high-priced digital Bendix/King KY197As (essentially a KX155 without the nav receiver). Avoid buying earlier KY197 units. They can be had for under $1000, but they could have receiver problems that require pricey repairs. A better choice is the KY97A, part of the Bendix/King Crown series marketed to homebuilders with lower price, lower quality display and lower transmit power. Beware that they have dull LCD displays—potential trouble for older eyes and difficult to read in the sun. A KY97A (14-volt) and KY96A (28-volt) can usually be had for $800-1000.


The only sane way to buy used avionics is with a thorough inspection by an avionics tech, which might as well include some pro wiring while you're at it.

ICOM's A200 com transceiver is a good radio. If you can find one for about the same price as a KY97A, consider it instead. Its display is also LCD, but it seems brighter with a better viewing angle. The Garmin SL40 is a decent com, with the same monitoring capabilities and GPS-pushed channeling we like in the SL30. If you find one for under $1300, snag it.

GPS and Nav Management Systems

Everyone lusts after a Garmin GNS 430 or GNS 530. Now that the legacy units are being replaced and upgraded to modern processors and WAAS capabilities, older GNS 430s and 530s are showing up on the used market. Mail order avionics houses now offer exchange programs for legacy boxes, which blows the used market wide open. By buying a used legacy GNS 430 or 530, you are getting older technology, but you can always upgrade the box (about $1500).

Don't pay more than $5000 or so for a used GNS 430, which should be complete with a GA56 antenna, nav datacard, mounting tray and connector kit. About $7000 is a fair price for the GNS

Photos: Larry Anglisano and Marc Cook

530. In either case, you'll need an indicator unless you plan to drive a glass panel, which isn't a problem because these units have ARINC 429/RS-232 and analog outputs. Be sure they have current factory paperwork and are up to current mod status.

If you plan to shoot GPS approaches with the earlier boxes, you might wrestle with a steep learning curve compared to newer units. An IFR KLN90B is worth around $1000, as is the Garmin GPS 155. You'll need accessories costing twice their value to make the interface full IFR. Buy a used GNS 430 if IFR GPS is in your future. Garmin's GNC 250XL, a GPS/com with moving map is worthy of its $1500-2000 used price. The GNC 250 is mapless and stark.

Squawking Transponders

Used transponders are tricky, and they are seldom a good deal. Any transponder that isn't solid state (one that uses a power cavity tube) is a risky purchase. Most replacement cavities for Bendix/King KT76 and Narco AT50 series transponders cost $600.

Even modern units like the Bendix/King KT76A and digital KT76C use a cavity. They are a reasonable choice—if in good order. KT76As bring $700 on average, while the digital KT76C is about $900. Better is a used Garmin GTX 327, a reliable digital and solid-state box. The GTX 320 series has mechanical tuning, but solid-state guts, and have proven to be reliable. You might find one in the same price range as a KT76A. The Mode S with traffic output GTX 330 transponder plays Datalink traffic on numerous displays including the GPSMAP396 and 496 portables. No deals here. Buy new and get the factory warranty. Forget Narco AT50s, Collins TDR950s and old King KT78s—you're asking for trouble.

Creaky old boxes moldering in the back room of an avionics shop: Do you really want them?

Buy Smart, Not Cheap

Lobby the help of an experienced avionics shop that can test and fully evaluate any used gear you plan to install. It's also a good idea to have the tech build wiring harnesses for the equipment. As is true for certificated aircraft, you need to do thorough research and weigh the cost differences between new and used equipment. In the end you'll be surprised to find that new equipment can cost less than old gear in the used market—with more capabilities. ✢

PART 5

The Home Machinist

We complete a project on the lathe.

BY BOB FRITZ

"This piece of work fills a much needed gap." Read that twice. Did it make sense? No? Good, you've just proven yourself capable of building this next part.

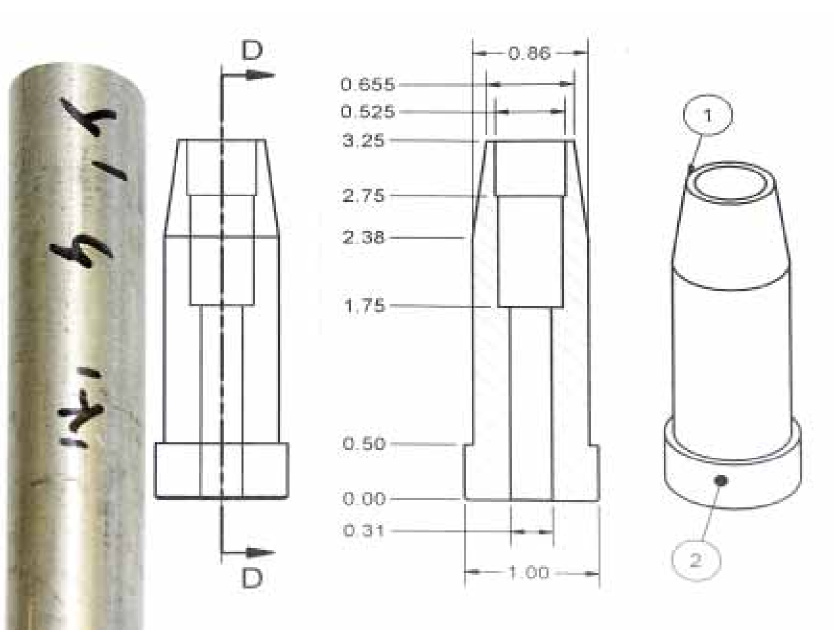
As promised in the last installment, this month we're going to make aluminum chips. Skybolt (*www.skybolt.com*) sells a really nice set of cowl fasteners that I used on my RV-6, but they require a special tool for installation. Now I know you can buy this item, and maybe you don't use their cowl fasteners, but it's a nice starter project in that it requires several basic operations and results in a useful, finished product.

Before we jump into this, there's one more thing you should buy. It's a little paperback book called *Machinery's Handbook Pocket Companion*. You can get it on the Internet for about $20. While it's not exactly Agatha Christie, it will solve a lot of mysteries such as what feed and speed to use with which material, and when it doesn't look right, what to do about it.

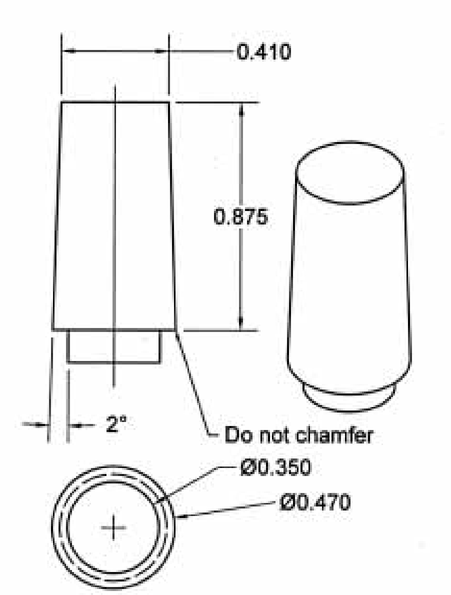
Also, before we proceed, a disclaimer. This series of articles is targeted to the reader who is curious about the basics and doesn't know what to ask much less what to buy. My use of a particular machine should not be construed as an endorsement or recommendation. Now on with the project.

Feed and Speed

You've probably heard these terms, but throw in surface feet per minute and you have three more pieces of that jigsaw puzzle I alluded to earlier. It seems obvious that a lathe with 20 or more different speeds must have them for a good



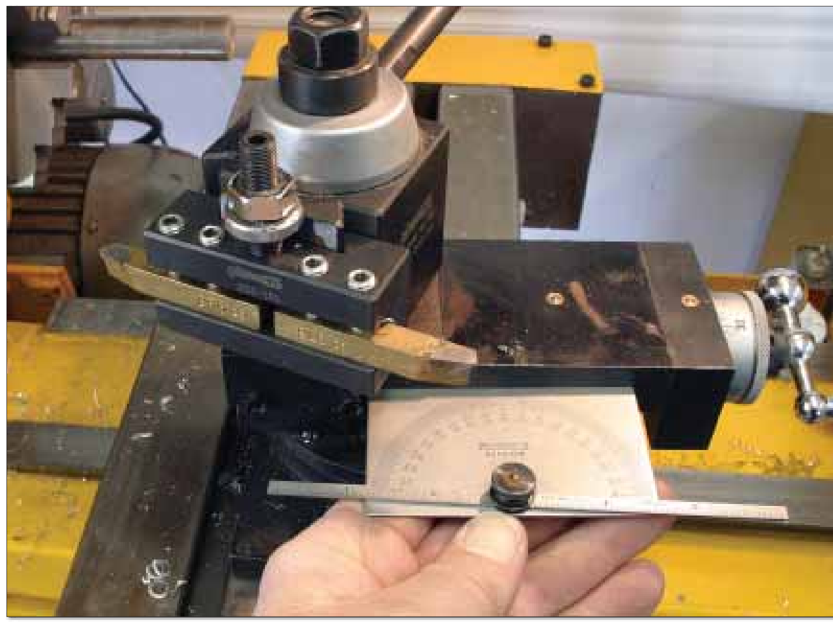
The push tool. The item in bubble 1 should be kept square; don't round it off. Bubble 2 is the knurled area. The marks on the material remind you of where to start/stop a cut, knurl or taper.



The expander tool. Make it from mild steel and note that the 0.470-inch dimension is the only critical area.

The 6-inch ruler leans toward the operator, so raise the cutting tool a bit.

Face off the end with the right-cutting tool.



Right- and left-cutting tools are in the same holder. We're holding the protractor against the compound-slide so as to measure its angle relative to the cross-slide. The angle of the tool doesn't matter...yet.

reason. Looking in *Machinery's Handbook* will explain, if not why, at least what rpm is needed for a given material.

We're going to start this project using 1-inch diameter aluminum. It should be obvious that turning a 1-inch diameter at, say, 500 rpm means the material will go past the cutting tool a lot more slowly than a 2-inch diameter piece would. The number you need to determine first, therefore, is sfpm, or surface feet per minute for a given material.

Review the handbook under "Cutting Speeds and Feeds—Turning—Light Metals" and on the appropriate page you'll find "All Aluminum Alloys—Turning 600/500 sfpm." To convert that number to rpm we could either calculate it or just go to Table 12a: "RPM for Various Cutting Speeds and Diameters." Looking across the top to 550 sfpm and then down the chart to 1 inch, we find 2100 rpm. Configure your lathe for that rpm and let's set up the cutting tooling.

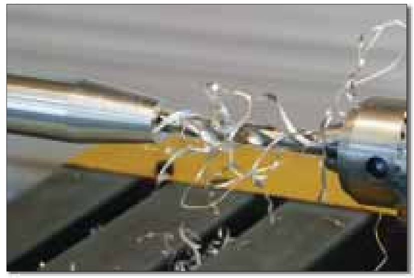
Selecting a cutting tool may seem a bit mysterious at first, but it's not nearly as tough as figuring out if the killer was Colonel Mustard or Professor Plum. Sure, if you're going for the ultimate in finish and speed, it becomes a science unto itself. But for our purposes, a

Start the taper and get a nicely curled chip.

Finishing the taper will take several cuts. No rush, just educate your hands as to what a clean cut feels like.

Center drilling removes any vestige of a high spot. This makes the subsequent drill bit find exact center.

Photos: Bob Fritz



You'll see chips like this to a depth of about three times the diameter of the drill bit.

Go more than five times the diameter of the drill bit and the chips usually start to pack in the flutes. Back out, clear them away and go back in. Repeating too much takes less time than digging out broken drill bits.

couple of general purpose cutting tools will suffice. All you have to do is look closely at the tool to see which way it slopes. If, with the shank of the tool towards you, the high edge is on the left, it's for cutting when moving to the left. Just look at the tool and you'll quickly figure it out. If it has no slope it's for cutting left or right, but won't give as pretty a finish as a specialized tool.

Facing Off

Our first operation will be to face off the end. Doing so will take the tool across the material from edge to center, which is also a left-to-right motion, so a right-cutting tool is required. Mount the tool snugly with at least two of the set screws in the tool holder. I like to use just two, because that way I can put another tool facing out the other end of the tool holder. That probably doesn't make a whole lot of sense yet, but it will later. Just remember that when you tighten something, make sure it's tight.

Now we have to get the cutting edge to be on the centerline of the material. With the tool in the holder and the set screws set, you can loosen the big nut on the top of the toolpost and spin the tool and holder around to get the cutting point to face the circumference of the material. Lightly tighten the big nut and then very lightly trap a 6-inch scale between the cutting edge of the tool and the stock. If the scale leans toward you, the tool is too low. Back off and adjust the tool up a bit and try again. When the scale is vertical, you're on target.

What I like about the quick-change tooling is that once the height is set and locked, you can pull that tool off and put another one on with the flip of a simple hand lever (the big red knob in the photo). Get them all set and you can really keep on trucking.

Now spin the toolpost around so that

The boring tool sets up a bit differently than the other cutting tools. You have to first rotate the tool in the holder to get the cutting angle similar to that of the other tools before you set the height. Then check the clearance under the tool to make sure that the only part touching the material is the cutting edge.

The knurl tool is simply two patterned wheels that push a pattern into the aluminum as if it were clay. Positioning the tool perpendicular to the aluminum will create a poor pattern.

Although you could cut the chamfer, a file does a dandy job. Note that the author is in short sleeves and is working without going over the rotating chuck.

Another quickie chamfer, this time internal. The author simply put a 1-inch deburring tool into a wood handle. A quick touch, and it's done.

the tool is in a position to cut across the face, and tighten the big nut. Your spouse probably thinks there's a big nut loose on both ends of the wrench, but we'll let that calumny pass for now.

The moment has arrived; we're going to make chips. Take a light cut of about 0.005 inch across the face of the material. For the first cuts you can either crank directly back or move to the right and then back. Reversing direction usually leaves a mark on the face, so going to the right to clear the material before backing off will prevent that and is good for making the final cut. Repeat this until all the saw marks are gone.

We're not a production shop, so take your time and learn the feel of the machine. This article is ground school and you're going to solo, so just take it easy and don't try aerobatics yet. Shut things off and take a close look at the end. If there's a tiny bump remaining you'll need to adjust your tool up or down half the diameter of that bump. Take another cut and now there's no bump, so tighten the lock nut on the tool holder and call it good.

Let's take a very light cut on the outside diameter to begin with. You're wearing the safety glasses, right? Set up a tool to make a left cut just as you did to make that face-off cut. I like to make the first cut by hand and very shallow, about 0.005 inch, to get the physical feel of the material and to ensure I've got the setup correct.

Once it looks good, you can take a second cut about double the depth and maybe try out the longitudinal feed. Just remember to test the feed lever for direction and feel. You don't want to be surprised to find it doesn't disengage easily.

As a precaution and as a practice, you might set the automatic shut-off. This is best done by cranking the cross-slide and the chuck well away from the material, then cranking the tool all the way to the left to where you want the cut to stop. Now, with the machine off, move the lever left/neutral/right and look for a corresponding motion of a long threaded bar just below the carriage hand wheels; that's your auto-feed. On that bar there are two large threaded cylinders, one to the left of the carriage and one to the right. When the carriage touches those cylinders it will disengage the auto-feed. Set the one on the left to stop the carriage where you want, and move the one on the right out of the way for now. Then try it out while keeping a hand on the lever. Once it works like you expect, make another light cut.

I like to mark my stopping points directly on the material with a felt-tip pen whenever possible. Just remember that for this part, the dimensions on the outside diameters are only approximates; we're whittling for now. You don't need to cut the area of the knurl at all. That process will cause the OD to increase, and the surface finish you start with will be destroyed in the process, so leave it alone.

The next step is to drill the center out. Start with a center drill. You'll find a lot of uses for a center drill because it's so stout. That strength is specifically to allow you to put a starting hole exactly on center. Imagine trying to start the hole using a 12-inch #40 drill; it'd wobble around worse than my dog did when my brother and I fed him some of my father's scotch. A short, stout drill is the just the ticket here.

Follow that with a drill to go full length. This hole is rather deep; in fact, the ideal hole has a depth only two to three times its diameter. One reason for this ratio will become apparent as you get more than an inch or so into the aluminum. When you start the hole you'll have two curled, wire-like chips

This is the finished first half of the tool with part of the cowl fastener sitting on it.

coming off. But as you get deeper you might not see anything. It's still cutting, but now the chips are packing the drill flutes. Back out and clean out the chips or you'll break the drill. For a hole this deep, you may have to do this five or six times.

Our last cut on the inside will be to bore out the 0.480 x 0.75-inch hole. Of course you could use a $^{31}/_{64}$-inch drill in this case, if you have one, but an inexpensive set of boring tools is a lot more fun and will always give you the size you want. The setup is the same as with the OD cutting tools. Just use a boring tool small enough to fit within the existing hole and put it on-center using the same 6-inch ruler technique as before.

You're beginning to see how these techniques build upon one another, so

This is a parting tool. Its a bit tricky to select, set up and use. We'll discuss it later. For now, simply saw off the almost-finished piece.

that what you learned in one technique is applicable to the next operation. That's an indirect way of saying I'm not going to repeat myself for the next part.

The inside diameter is important, so try to hit it within a couple of thousandths of an inch. The depth on the push tool is clearance, so go to the num-

Cutting the taper this way makes it easier to cut the step.

The other half of the cowl-fastener tool is a simple part, but it's useful for learning how to work in steel.

Place the large half of the tool onto the taper, push the steel ring down the taper, and snap it on to the receiver.

ber and a bit beyond. You'll see how this all fits together at the end and it will make more sense than the opening paragraph, I hope.

Now let's cut that taper. The angle and outside diameter aren't really important; close enough is good enough. Just set up a left cutting tool on-center as you did before. You can use that same tool holder that is holding the right-cutting tool, just put the LC tool in the unused half of the holder and then swivel things around until it sets up correctly. Now you have a fast way of switching tools.

A pair of locking nuts are just above the cross slide, which will allow you to spin the compound slide around to achieve the 2° angle. As I said, the angle is not critical; it's just visual clearance. All that remains is to check clearance and make sure you have enough travel on the compound slide to go the full length of the cut. If you do, have at it. This is getting easy, right?

On to the Knurl

This is simpler than you might think. There are two tricks to the operation, though. The first is to get the tool to the right height. With the rpm turned down to as slow as possible, bring the two wheels up to the material so that they barely touch. One of them will turn, and the other will not. Raise or lower the tool as needed to get them both to turn at the same time without leaving a mark on the aluminum.

The second trick is to rotate the tooling clockwise about 0.5°, i.e., just a smidge. If it's square to the work you'll get a lousy pattern. The nice thing about knurling is that if it's not right on the first pass you can adjust the tool and take another; this is squashing the aluminum as if it were clay and in so doing, removes the previous pattern.

Simply advance into the aluminum to give a light pattern and engage the feed to drive the tooling to the right. Back out, go to the beginning and repeat until you have a good, clean pattern. How deep is up to you. Go too deep, though, and you can create points that are hard to hold on to. I then like to take one last pass with the left-cutting tool to clean up the interface between the OD and knurl, then a light pass over the knurl to make the pattern look really clean.

Although we could use the parting tool, I don't really like to as it's tricky to set up; so for the moment, we'll avoid it and simply saw off the part with about 1/8 inch to spare. Clamp it back in the three-jaw chuck, face it off, and add a chamfer to make it look good. Grin and give yourself an attaboy.

The second part of this tool is much like the first. The big difference is that it's made from steel, so you'll need to go into the handbook for feed/speed and sfpm again. These numbers should be about one-quarter that of aluminum, and the part might benefit from the use of some cutting oil to keep the heat down. Just drip a bit onto the cutting zone as you go.

Also note that this part is easier to make with its taper facing the other way. Try it both ways to see what I mean. It'll be obvious once you attempt to cut the small diameter along with the maximum diameter of the taper. Oh, and that maximum diameter of 0.470-inch is really the only critical dimension. Make it too small, and the snap ring won't expand enough to go over the mating part. Go more than, say, 0.480 and you're doing more work than is needed when using the tool. Surface finish on the expander is also important. The snap ring will hang up on grooves or roughness. Wet or Dry sandpaper works well to get a good finish, and it's better used wet than dry. I like to use chainsaw oil because it won't fly off so easily.

Even if you aren't using these cowl fasteners, the operations we've shown are essential to almost anything you might want to make, so go make chips! Oh, and that starter paragraph about filling a much needed gap? It was in a movie review. Kind of twisted my eyes around until I figured out what it meant versus what it said.

Editor's note: If you have specific questions for author Bob Fritz, or if you have certain projects you'd like us to cover, email us at editorial@kitplanes.com with "Home Machinist" in the subject line. ✢

ENGINE BEAT

BY TIM KERN

Rotax *two-stroke school.*

Little in the operation or maintenance practice of one aircraft engine does not translate to another. Precision, cleanliness, attention to the manual, assembly and safety-wiring, attention to torque values, currency with Airworthiness Directives and Service Bulletins—good practices are good practices regardless of the engine you're working on. Like the 912 series, the Rotax 582 comes in both LSA-compliant and non-compliant versions. Unlike the 912... well, everything else is unlike the 912. I continued my education with the Lockwood schools—officially, Dean Vogel's Aero Technical Institute. Last issue, I covered the 912 school. Now it's on to the two-strokes.

Dean Vogel, founder of the Aero Technical Institute, explains different signs of wear on pistons. Different oils do make a difference, so follow Rotax's research.

Vogel's the Man!

Vogel's Aero Technical Institute classes at the Lockwood facility in Sebring, Florida, are targeted to two levels. The one I attended was a two-day course, tailored to owner/operators; there is also a three-day repair center course, which is one of the requirements for becoming a Rotax-approved repair center.

In the course, Vogel stresses the need for attention to every detail of care and feeding, from choosing proper oils to assembly techniques, as well as routine and detailed inspections. While a significant amount of information about the engine's health can be gleaned by merely looking through the intake or exhaust ports, a complete overhaul every 300 hours is a good idea, which seems short until you consider that many recreational flyers put on fewer than 50 hours a year; many much less than that. Six years of flying between overhauls is not an unrealistic maintenance requirement.

Some items are best left to the repair stations, in any event. It is hard to overestimate the amount of torque required to properly service the gearbox, for example. Additionally, clearances required in that box are precise, and the substitution of, say, a too-thin spacer can mean that your Avid Flyer will become a windmilling glider, possibly at a bad time. (Is there ever a *good* time?)

Rather than worry about heavy maintenance, Vogel urged us to be vigilant for the signs of impending trouble: scratches, gouges and sudden buildup in the cylinders, rattling in the gearbox, rough running. He had us more deeply explore techniques that would help us avoid trouble in the first place.

Most importantly, we learned that we must keep things from falling off, unscrewing themselves, breaking and getting clogged. Also important was keeping up with Service Bulletins and Airworthiness Directives. Though the two-strokes have shown little SB activity in recent years—and there are no ADs—there are plenty of older units in the field that are in need of updating. (A subscription to the Rotax SB service is free at *http://rotax-owner.com*.) Additionally, with a five-year/300-hour general overhaul cycle, any unknown or used two-stroke should get a thorough going-over at an authorized repair center before it takes your body into the sky. Fortunately, because of their low parts count, two-stroke rebuilds are way less expensive than four-strokes'. After a proper rebuild, you'll be flying with a solid, like-new engine, all up to date and full of compression.

An Exhausting Topic

Proper safety-wire techniques, particularly on the semi-moving parts that comprise the critical exhaust system, must be followed. Too tight, and the safety wire can cut through other parts or simply break; too loose might actually be OK, as long as the major hardware is in good condition and as long as you do thorough preflights. Using silicone sealants to augment the safety wire and damp vibration is another good idea.

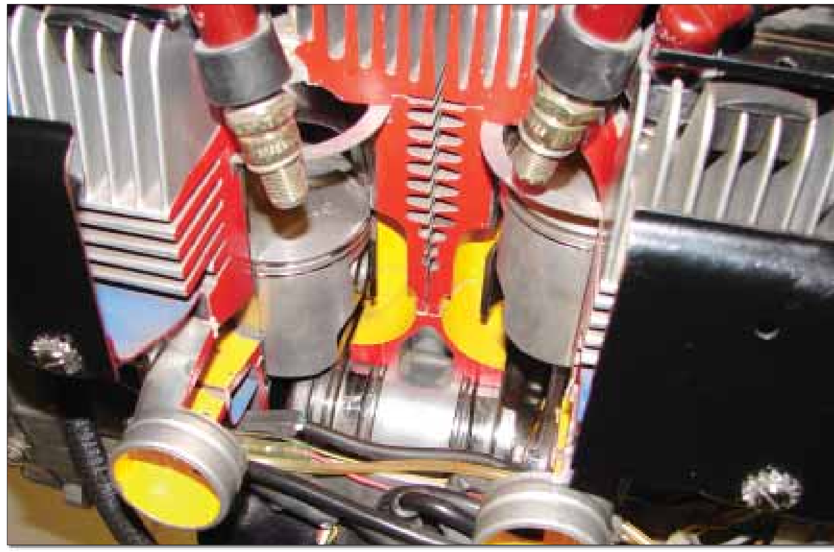
Tim Kern's start in homebuilding came early, as he helped his dad build Luscombes and a wood glider as a kid. Since then, he's been involved in building three homebuilts: a Preceptor Pup, a Range Rider and a Baby Lakes. From a professional background in motorcycles and auto racing, Tim began his aviation career at Mosler Engines in 1990. Visit his web site at www.timkern.com.

Shop rags and plenty of attention keep each small-end's 37 free needle rollers out of the big end.

The carburetors wear, too. Specifically, the Viton seal on the float valve can take a set and suddenly stop sealing. Although this is not often a huge problem in the air (you'll run too rich, giving you some warning), it can be inconvenient in the hangar when you've returned to find fuel all over the floor. The solid-foam floats will never sink, but may wear on the pins that trigger the float valve. When you see that, flip the floats over—they're symmetrical—but check the float-valve hinge for wear. The jet needles can develop flat spots, particularly in the older carbs, which do not have the O-rings that reduce the rattling that naturally occurs. Likewise, the brass needle jets can wear from the constant rattling of those needles, richening the mixture in an unpredictable way. When either part wears, the only solution is a low-cost replacement.

We disassembled a Rotax 503 in class (the 65-horsepower Rotax 582 is the only ASTM-compliant two-stroke for SLSA use, but the internals are similar), learning the importance of some essential special tools, such as the fixture that keeps 37 needle rollers in place when piston pins are removed or installed.

Photos: Tim Kern



Mysteries revealed: Cutaway shows relationships among assembled parts, demonstrates how a two-stroke breathes and why internal sealing is important.

There are techniques that make cooling-fan belt replacement easier and procedures that keep you from having to take the engine back apart because of skipping a step. Vogel covered the timing and ignition system, troubleshooting and setting it up. It's simple, once some techniques are learned. (Because the spark plug holes are angled in the head, you'll need a little trigonometry to determine just exactly when the piston is in position before top dead center. Each model has a different plug-hole angle, so it's good to follow the manual as you translate your dial gauge's reading into millimeters BTDC.)

Then we went down to the hangar, where we looked at some proper installations. As with the 912, the cooling system is critical. The 582 does not need special coolant, but the system does need to be routed correctly, purged of air and maintained inside the engine. The placement of the fill tank and radiator, relative to the engine and its coolant ports, was demonstrated. (It's all in the installation manuals; the checklist is too detailed to explain here.)

As for operating tips, they fall into a few broad categories: Use higher rpm in cruise (the expansion chamber operates more efficiently at higher rpm), and don't idle too low (it beats up the gearbox); be sure the engine is up to temperature before taking off; use quality oil and fresh unleaded premium (100LL leaves heavy lead deposits), and have a frequent look at things that wear (e.g., carb parts) or could fall off (like the exhaust system).

When your aircraft is to be stored longer than a month, drain all the gas from the tank and float bowls and give the systems and carbs a good shot of corrosion protectant. When it's time to fire it back up, use a detailed checklist, check everything for leaks (including air leaks at the carb boots) and loose parts, and be sure that moving parts (especially in the carbs and the exhaust system) move freely. Check your oil level, use fresh gas, and you'll be ready. Then check everything again before you fly.

Two-strokes don't have to be scary, and this course is a great way to understand them. Follow the directions and pay attention, and that about sums up the way to fly many, many safe hours. ✢

For more information on Vogel's school, call 863/655-5100 or visit www.aerotechnicalinstitute.com.

BY JIM WEIR

Flash yourself, Part 2.

So we've come to the point in this project where we have about 3 joules of energy (100 microfarads of capacitor charged to 300 volts) ready to light up our lightning bolt in a bottle. Now it becomes our job to see how to make that lightning happen.

Here's the deal: 300 volts across an almost empty tube of xenon and vacuum isn't enough to start the flash going. However, if we put a very large (6000 volt) electric field over the *outside* of that tube, that will be enough to start the spark. Once the spark starts, it doesn't quit until that entire capacitor of charge is fully used up, and 3 joules of spark is a fairly bright light for a few milliseconds (see later comments).

Hold on a Second

So we went to all that trouble to generate 300 volts from 12 volts last month, and now you are telling me that we need to generate another 6000 volts? Yes, but only for a few hundred microseconds. Just like a real lightning bolt only needs a couple of hundred microseconds of "leader" to start the plasma discharge, so our miniature lightning bolt needs the same thing. Just start the spark and the xenon gas will take care of the rest.

This small flashtube was used for experimentation.

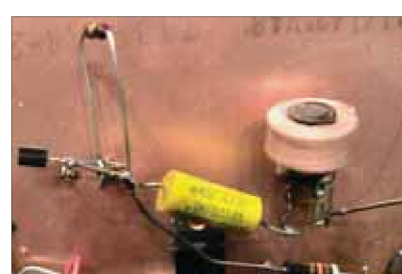
T1 in the accompanying schematic is the spark starter. If you give the primary of T1 (the left-hand coil) a shot of 300 volts for a few hundred microseconds, it will induce a 6000-volt pulse into the right-hand secondary. Pulse the primary, fire the secondary, start the arc (plasma) in the lightning bottle, and away we go.

That's not too hard. Charge up a decent size capacitor (C2, 100 nanofarads) to the 300-volt supply through R3, which should happen in about 5 milliseconds, and then snap discharge it. It will induce that 300-volt pulse in the primary, which reflects a 6000-volt pulse in the secondary.

Snap discharge? That sounds like a job for an SCR (silicon controlled rectifier), one of the lesser lights of the semiconductor arsenal. Most semiconductor devices are at least marginally analog. That is, you can put in a little voltage, and it will give you out a little voltage. Put in a little more, it will give you out a little more. Put in a lot, it will give you a lot out. SCRs aren't that way.

Put in a little voltage to an SCR, you get nothing. Put in a little more, nothing. Put in just a *little* more, and you get the whole power pile out—nothing held back. In particular (see the schematic) when the gate (the little arm coming in from the left) is less than a volt, the SCR does not conduct current at all. When the voltage rises just a few millivolts above a volt, the SCR all of a sudden conducts amperes of current instantaneously. Even if the gate voltage drops below a volt, the SCR keeps conducting until the voltage at the anode (the black pointy terminal) drops to zero—the very definition of a "bang-bang" switch.

OK, then let's figure out how to make our 300-volt supply trigger this little rascal. Actually, the 300-volt supply is adjusted (last month) to rise to 350 volts under no load. With no load being no current through the lightning bottle, the voltage at the anode of Q1 will rise from zero at turn-on to approaching



Left to right: the small black SCR, the yellow 100 nf flash capacitor, and the orange 300:6000 volt flash transformer.

Jim Weir began acquiring Aero'Lectrics expertise in 1959, fixing Narco Superhomers in exchange for flight hours. A commercial pilot, CFI and A&P/IA, Jim has owned and restored four single-engine Cessnas. These days, he runs RST Engineering and teaches electronics at Sierra College. Ask him questions at rec.aviation.homebuilt or visit his site at www.rst-engr.com/kitplanes.

Photos: Jim Weir

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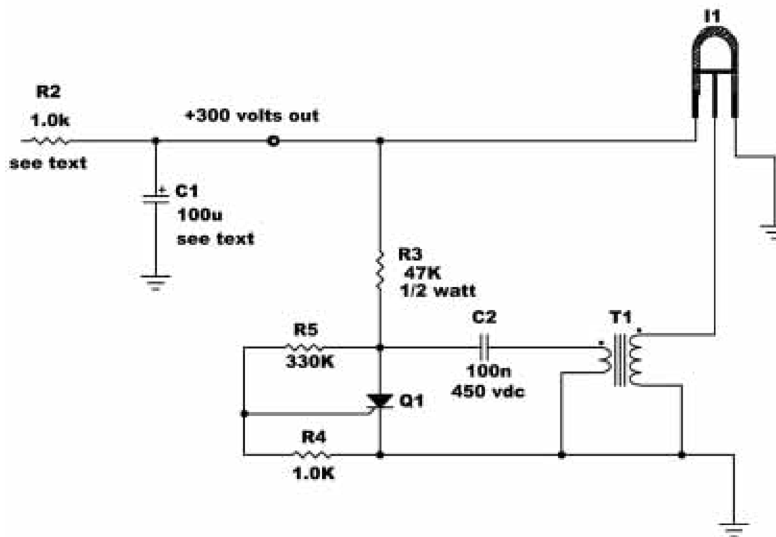
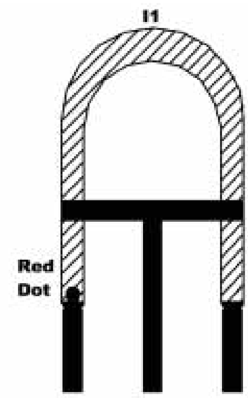
The schematic.





Reference Designator	Value	Mouser Part Number
I1	60-joule flashtube	36FT106
T1	300:6000 volt transformer	422-3306
C2	100nf 450-volt capacitor	146-630V.1k
Q1	400-volt SCR	511-XL08040

350 volts until the R4/R5 combination puts a volt on the gate of Q1 at 331 volts. BAM, the SCR turns on, discharges C2, T1 fires the 6 kilovolt bullet to the lightning bottle, and 330 volts is discharged in a few milliseconds through the bottle.

Then the good old power supply keeps on trucking and starts pumping C1 back up to 350 volts and when it gets to 330 volts, BAM...then BAM...then BAM. (John Madden, eat your heart out.)

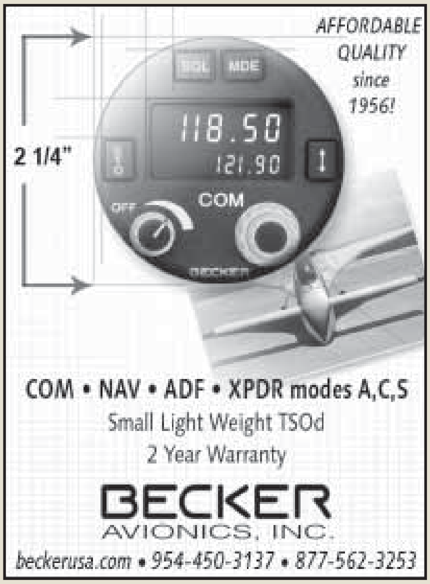
Temporary Deficiencies

There is a downside to doing it this way. First, that strobe is bright, but not blindingly bright. I've been working on the top of the tailfeathers when somebody accidentally lit off the strobe, and *that* sucker is bright. Second, we are somewhat dependent on the battery voltage to set our strobe's repetition rate, and that's not good. That is, with a low battery voltage the strobe will appear to slow, as the power supply takes longer to charge the capacitor and thus fire the SCR. Third, we are wasting a lot of power in that 10Ω input resistor just to be sure that our power supply doesn't overvoltage and destroy the 100 µf 350-volt energy storage capacitor.

We'll take care of all these deficiencies next month. Right now, let me give you a source for all the critical parts we used this month so that you can at least get started playing around with this design.

Hey, for twenty bucks in parts, you can be up and messing around with things that are several hundred dollars from the parts houses. Not only that, but your replacement parts are measured in dollars, not dozens of dollars. Oh, and for those of you who have installed the commercial strobes and have had a tube go bad, you really might want to look at the Mouser line of flashtubes for less than $20 apiece. Now I would never tell you to replace a genuine aircraft part with some commercial equivalent, but I have this friend Ernie...

Next month: the ultimate strobe. Following? I dunno. How about the ultimate external GPS antenna (blatant commercial hucksterism), some thoughts on solar power for the hangar, and a few more goodies up my sleeve. Stay tuned. ✢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WIND TUNNEL

BY BARNABY WAINFAN

The inherent compromises of a fixed-pitch propeller.

The job of a propeller is to take the power developed by the engine and convert it to thrust that propels the airplane through the air. Proper matching of the propeller to the engine and the flight condition at which the airplane will operate are essential to getting good performance from the airplane.

Thrust Horsepower

As the propeller rotates, it accelerates air aft. This, in turn, generates a reaction force forward on the propeller blades. This reaction force is the thrust that drives the airplane forward. The thrust horsepower is the thrust generated by the propeller multiplied by the airspeed (in appropriate units). If the propeller were perfect, and had an efficiency of 100%, thrust horsepower delivered by the prop would be equal to the shaft horsepower delivered to the prop by the engine. In fact, even an ideal propeller of finite diameter cannot achieve an efficiency of 100%, so the thrust horsepower out is always a bit less than the shaft horsepower in. By proper design and selection of the propeller, we can minimize this difference and maximize performance.

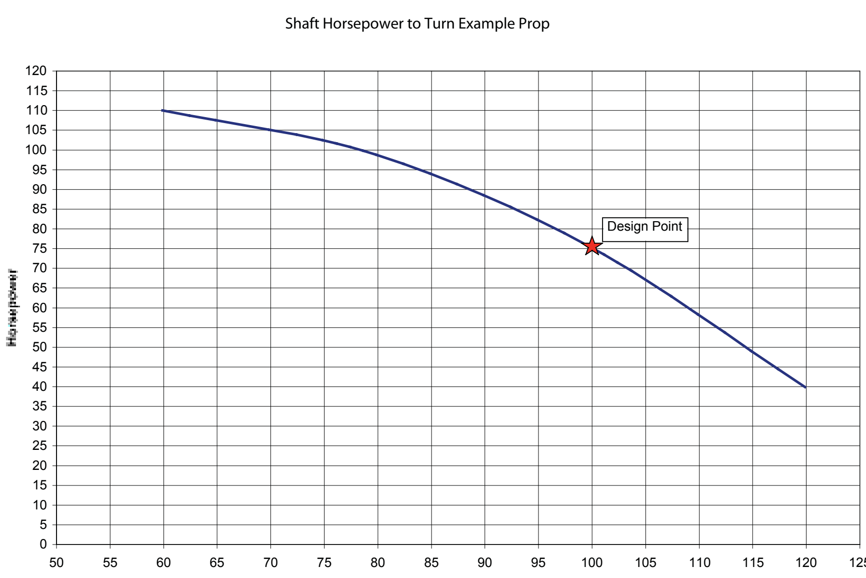


Figure 1.

Barnaby Wainfan's day job is in aerodynamic design for Northrop Grumman's Advanced Design organization where he is a principal engineer. 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.

The thrust horsepower delivered by the propeller to the airframe to drive the airplane forward is a function of two things: the shaft horsepower from the engine that is driving the propeller and the efficiency of the propeller itself. Both of these vary with airspeed and propeller rpm.

Shaft Horsepower

As the propeller rotates, the pitch set into the blades gives them an angle of attack relative to the incoming air. This angle of attack causes the blades to develop the aerodynamic lift that generates thrust. The torque of the engine drives the propeller and overcomes the drag of the blades.

For a propeller at a given rpm, the angle of attack of the blades changes with airspeed. As the airspeed increases, the oncoming airflow approaches the propeller disk from the front, which is the "upper" or suction surface of the airfoil of the propeller blades. This reduces the angle of attack of the blades.

The reduction in angle of attack of the blades has two effects: It reduces the lift of the blades (and hence their thrust), and it reduces their drag. Accordingly, as airspeed increases, the power required to turn the propeller at the specified rpm goes down. If the airspeed gets high enough, the angle of attack of the blades becomes negative, and the airstream starts to drive the propeller like a windmill.

Figure 1 shows the power required to turn an example propeller at constant rpm. The example propeller was designed to absorb (be driven by) 75 horsepower at 2600 rpm at an airspeed of 100 knots. At 80 knots airspeed, this same propeller needs 98 hp to maintain 2600 rpm, and at 120 knots, the prop only needs 39 hp to maintain 2600 rpm.

This behavior has several important implications. The amount of power

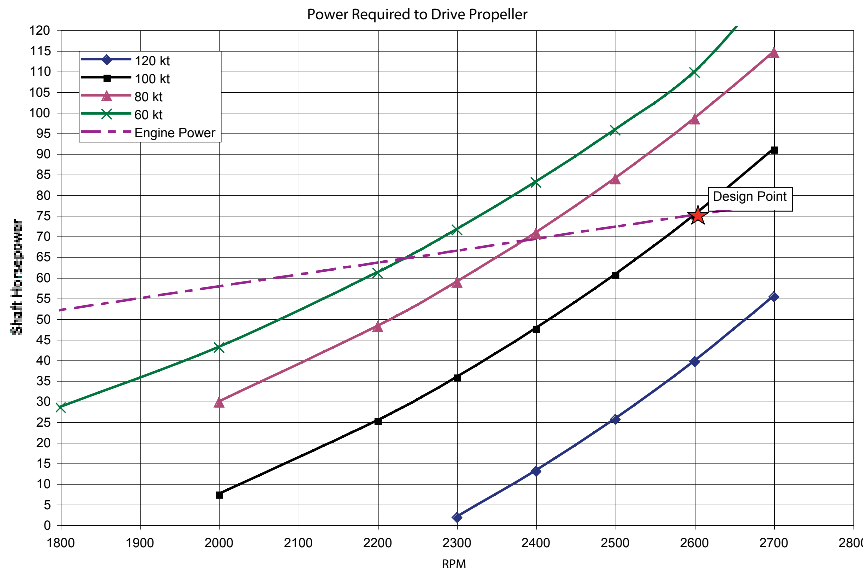


Figure 2.

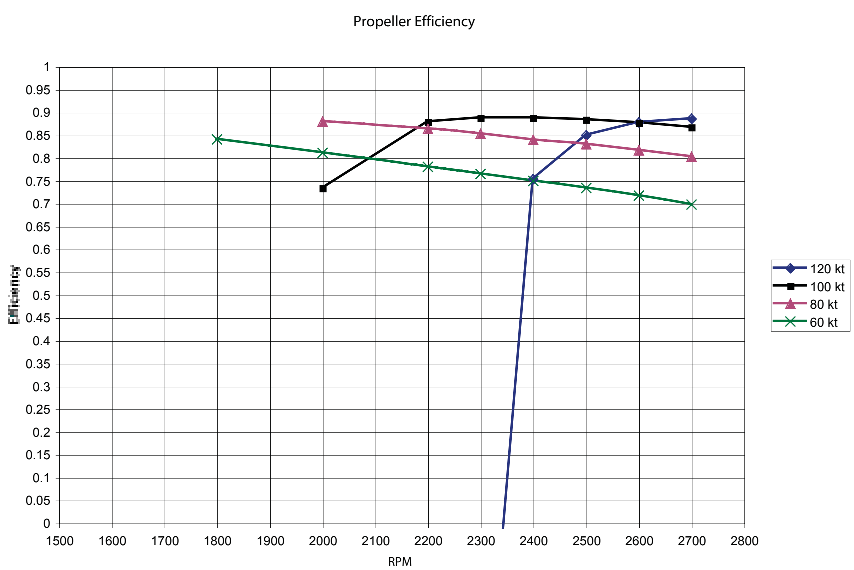


Figure 3.

required to drive the propeller at a given rpm is also the maximum amount of horsepower the propeller can apply to the air to make thrust at that rpm and airspeed. Flying faster than its design point, a propeller can't absorb the full design power without turning faster than the design rpm.

The second effect is that the engine may not be able to drive the propeller at the rated rpm at airspeeds below the design point. If this is the case, then the propeller will govern the engine to a lower rpm and lower horsepower.

To see how this works, refer to Figure 2, which shows the power absorbed by our example prop as a function of rpm at several airspeeds. The figure also shows the power the engine driving the prop can deliver at full throttle as a function of rpm. If we look at each constant-airspeed propeller power curve in turn, we will find an rpm where the power absorbed by the propeller matches the full-throttle power the engine can deliver. This is the rpm at which the prop will spin at that airspeed. That equilibrium rpm, in turn, determines how much power the full-throttle engine is developing while turning the propeller at that airspeed.

If we follow the 100-knot airspeed curve, it intersects the engine curve at 75 hp and 2600 rpm, which is the design point for this propeller. At 80 knots, the propeller governs the engine down to 2380 rpm, at which it produces 67.5 hp. Reducing the airspeed further, to 60 knots, loads the prop blades even more, and the prop holds the engine down to 2230 rpm and 64.5 hp.

At 120 knots the picture changes. The propeller cannot absorb the power the engine can produce at full throttle, even if we allow the rpm to increase to 2700. Assuming the airplane gets to that speed, the pilot will have to retard the throttle to avoid over-speeding the engine, so that the power delivered to the propeller will drop to 50 hp if the limit is 2700 rpm.

What we see here is the essential compromise inherent in choosing a fixed-pitch propeller. We want the prop to efficiently absorb the cruise power of the engine at our desired cruise airspeed and altitude, but we also need it to be able to deliver enough thrust for takeoff and climb. A cruise-optimized propeller is likely to govern the engine too much at low speed, particularly if the airplane is clean and relatively fast. The more airspeed difference there is between cruise and climb, the further the prop will be from its cruise operating condition in climb. This is why we tend to use propellers that are a compromise. They have a bit less pitch than would be optimal for cruise in order to improve takeoff and climb.

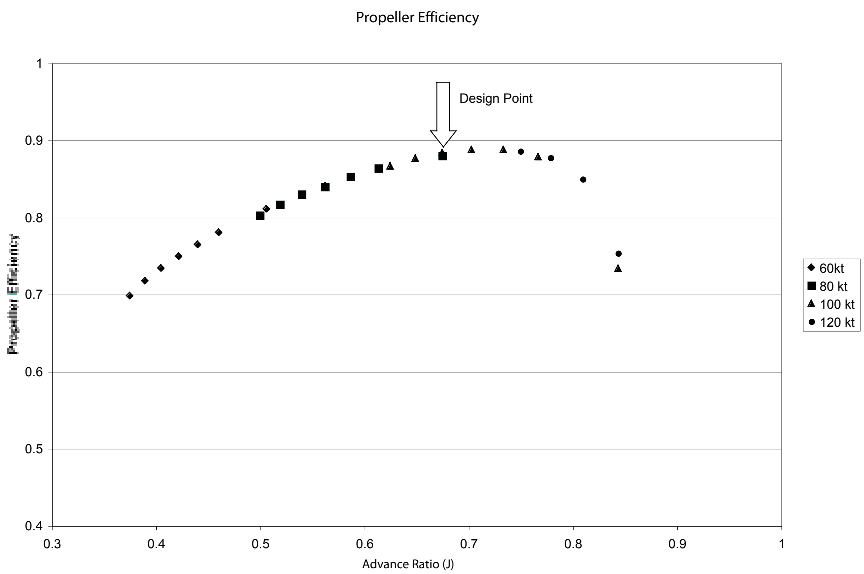


Figure 4.

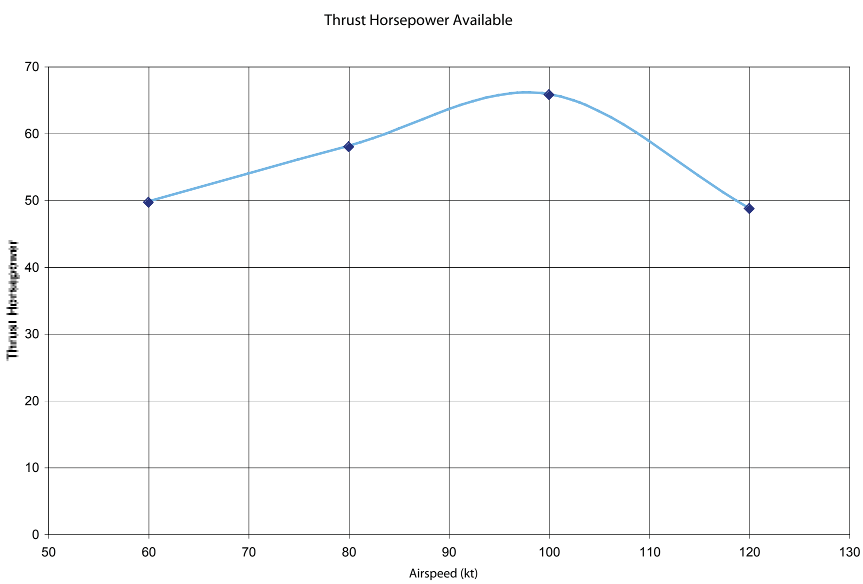


Figure 5.

Efficiency

The variation in thrust horsepower with airspeed is also affected by the efficiency of the propeller. The propeller efficiency is the ratio between the thrust horsepower generated by the prop and the shaft horsepower required to turn the prop. Figure 3 shows the efficiency of our example propeller as a function of airspeed and rpm. The important thing to notice is that the propeller efficiency drops significantly when it is operating far away from its 2600-rpm, 100-knot design point.

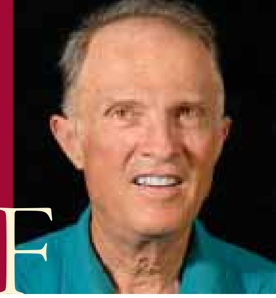
Plots like those in Figure 3 are a bit difficult to use, so propeller designers have evolved a way of combining all of the curves at varying airspeeds and prop speeds into a single curve. We do this by defining a quantity called the "advance ratio" of the propeller. The advance ratio (signified in equations by "J") is the airspeed in feet per second divided by the diameter of the propeller in feet and the rotational speed of the prop in revolutions per second.

Figure 4 shows the efficiency of our example propeller as a function of advance ratio. Notice that the efficiency of the propeller drops steadily as the advance ratio (and hence the airspeed) drops below the design point. This reduction in efficiency further reduces the thrust horsepower the propeller can produce at airspeeds below the design point. Not only is the shaft horsepower reduced, as we saw earlier, but the propeller is less efficient at converting that lower horsepower to thrust.

Figure 4 also shows why we don't want to move the design point to too low an airspeed while trying to improve climb. Notice that above a certain advance ratio, the propeller efficiency falls rapidly. We must ensure that our airplane isn't trying to cruise in the region of poor propeller efficiency.

Available Thrust Horsepower

In total, the thrust horsepower available from the engine/propeller combination at any given airspeed is the product of the power absorbed by the propeller from the full-throttle engine and the efficiency of the propeller at that flight condition. The thrust horsepower available from our example engine/prop combination is shown in Figure 5. The maximum thrust horsepower available occurs at the propeller design point for a well-matched engine and prop. At lower airspeed, thrust horsepower is diminished by the combination of the propeller governing the engine to a lower shaft horsepower and reduced propeller efficiency. At higher airspeed, the need to reduce throttle to avoid overspeeding the engine and lower propeller efficiency also reduce the thrust horsepower available. ✢



BY DAVE MARTIN

The RANS S-7S Courier Light Sport.

The RANS S-7S Courier is the product of evolution, and it has changed considerably over the last two decades. For example, since the first S-7 flew in 1985, the empty weight and the engine power have both doubled. Originally intended as a two-seat trainer for the company's single-seat Coyote II ultralight, the Courier is now on the factory-built SLSA market, but it's still available as an Experimental/Amateur-Built kit that qualifies as a Light Sport Aircraft.

The factory-built S-7S Courier SLSA is the latest iteration of a long-lived design by RANS President Randy Schlitter. The first S-7 flew in 1985.

The Company

RANS has a fascinating history that started in 1974 with a land-based recreational vehicle called a Sailtrike. It combined one or two seats, three wheels and a sail that could propel it close to 60 mph in Kansas winds, but it could also be pedaled. Sailtrikes were manufactured through 1981, but during those years RANS President Randy Schlitter was also interested in flying, so he partnered briefly with a friend to produce the Aero-max Coyote ultralight, powered by a 28-horsepower Rotax 277.

Aero-max didn't live long, but the Coyote ultralight did, and Schlitter soon designed other ultralights including the S-7 Courier trainer. At about the same time, RANS developed a line of high-quality recumbent bicycles—a product line that continues and includes other high-end lightweight bikes.

Through the years, Schlitter's prolific pen and computer have produced successful kits for a wide variety of his designs including the S-6 Coyote II, S-10 Sakota, S-12 Airaile, S-18 Stinger and now the S-19, designed specifically to fit (just barely) into the Light Sport Aircraft definition. At this point the S-19 is being sold only as a kit, making the S-7S Courier the only RANS available as a ready-to-fly SLSA. (See the May 2005 issue of KITPLANES® for a Designer Spotlight profile of Schlitter.)

The Airplane

With the exception of unusually good visibility from both seats, nothing about the S-7S is particularly innovative. But the Courier is a testament to the company's long experience designing sport aircraft and its reputation for turning out high-quality kit parts. Attention to detail and the use of aircraft-grade materials are apparent in the entire RANS line, including the factory-built S-7S.

The wingstrut system and landing gear legs are examples. Struts are anodized airfoil-shape extruded aluminum with welded steel jury struts to hold them in column. Strut end fittings are CNC-machined. Landing gear legs are spring steel, but they are nicely faired for drag reduction and cosmetics. The gear system features a steerable tailwheel that swivels fully on demand plus aircraft hydraulic brakes, wheels and tires. RANS notes that the S-7S is designed to operate on grass strips. Baggage capacity is 50 pounds.

For a high-wing airplane, the Courier's cockpit visibility is exceptional. The top of the cowl is low, resulting in excellent forward view, even while taxiing. The windscreen and 5-foot-long side windows are tall. In steep turns, a huge overhead Lexan window between the wings allows both occupants a view from below the horizon to straight up. The welded chrome-moly steel fuselage features a 30-inch-wide cockpit with seats that move fore and aft. Headroom in the front seat, which is the solo position, is a whopping 42 inches, and it's 36 inches in the back seat.

Standard equipment includes dual controls (stick, rudder, throttle and

Dave Martin, who served as editor of this magazine for 17 years, began aviation journalism evaluating ultralights in the early '80s. A former CFI (airplanes, gliders, instruments), he's flown more than 160 aircraft types plus 60 ultralights (including a single-seat, no-basket hot air balloon). Now living at a residential airpark in Oregon, he flies his Spacewalker II homebuilt as a Sport Pilot.

Photos: Dave Martin and Kim Dopita (Courtesy RANS Aircraft) brakes) plus electric pitch trim on the front stick and the flap lever up front. Avionics include a choice of a Bendix/King or Garmin for both GPS/com and a transponder. Cabin heat, an ELT and a PS Engineering intercom are included.

Up front, the two-piece cowl removes quickly with quarter-turn fasteners to reveal the 100-hp Rotax 912 ULS. Oil is checked through a cowl door. The 72-inch Sensenich wood propeller comes with a urethane leading edge and a 13-inch spinner. Fuel consumption (preferably auto gas, according to Rotax) is listed at 5 gph at 75% power. Rotax's recommended TBO is 1200 hours.

Rudder and ailerons are controlled with cables through ball bearing aircraft pulleys, and a push-pull tube operates the elevator. The airframe is covered with 2.8-ounce fabric, and RANS offers a considerable range of paint and trim schemes. One S-7S feature not seen on most airplanes in this category is aileron spades. They lighten aileron forces and are most often found on aerobatic aircraft. Courier design gross weight is 1232 pounds, and empty weight is 750 pounds. Filling the 18-gallon tank would leave about 377 pounds for people and baggage.

Let's Go Fly It!

Schlitter and I checked the cockpit, then walked around and appropriately inspected N477PW, which was at this year's Sebring LSA Expo as a demonstrator. After pulling the Courier away from the crowd, we climbed aboard and started the engine in normal Rotax 912 manner. Paying attention to significant surface gusts, we taxied in standard taildragger fashion.

The takeoff run was short, and the solid feel associated with a heavier airplane was immediately apparent in the somewhat bumpy air. The turbulence-affected rate of climb was close to the advertised 850 fpm. Also noted was the relatively quiet cockpit; I removed my headset briefly to check it.

After climbing into smoother air at about 2000 feet, we got to 110 mph

Good design, aircraft-grade materials and excellent workmanship result in an obviously durable airplane that is a joy to fly.

indicated at full power. Even with aileron spades and small elevator extensions forward of the hinge point, controls are somewhat heavier than most homebuilts, but that is appropriate for airplanes licensed in the SLSA category. Required pressures are well balanced among the three controls. That's due in part to the differential ailerons (more up than down movement), which reduce adverse yaw and rudder pressure to keep the slip/skid ball in the center.

Slow flight at 55 mph, 3600 engine rpm, was comfortable, and stalls with and without power were docile with the slip/skid ball centered. Schlitter demonstrated uncoordinated control inputs in slow flight. Nothing untoward happened, but we would both recommend not flying like this below safe stall-recovery altitudes.

The Courier's roll rate of 2.5-3 seconds from 45° one way to 45° the other is typical of SLSAs. The airplane is not strongly pitch stable, but certainly adequate. That is, the airplane slowly returns to trimmed airspeed and attitude hands off a few cycles after being disturbed in pitch.

Heading back to Sebring, we descended into the rough air but made a graceful three-point landing including use of the flaps, "flying" the S-7S while taxiing to the engine-shutdown spot.

I like the Courier a lot. A good guess is that any competent taildragger pilot would also appreciate its handling in addition to the top quality fit and finish of this latest edition of the long-running RANS S-7 line.

Buying One...or Building It

In addition to the ready-to-fly, well-equipped SLSA S-7 (which sells for $80,000), a kit version is still available. The airframe basic kit price is $18,745 if the builder intends to install a 100-hp Rotax 912S, and a little less for the 80-hp Rotax 912 version. Including the 100-hp Rotax, instruments, basic avionics, upholstery and paint, RANS estimates the finished price at $35,388—plus 500-700 hours of work. Quickbuild options are available.

Either way, the S-7S Courier is expected to please a large number of Sport Pilots, especially if they are inclined to buy a U.S.-made aircraft.

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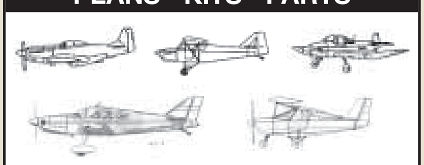

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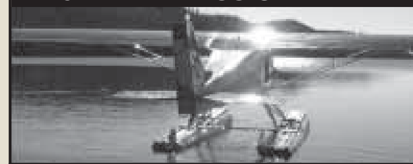

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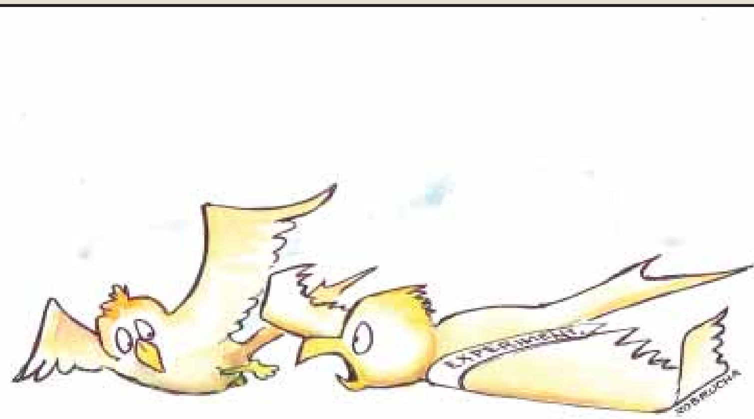

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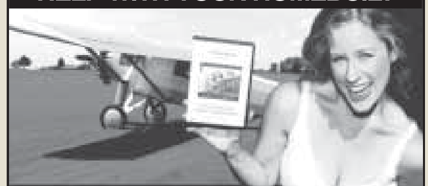

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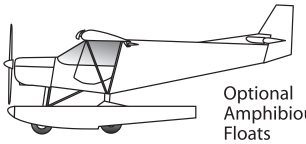

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