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# CONTENTS

June 2007 | Volume 24, Number 6



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THE INDEPENDENT VOICE FOR HOMEBUILT AVIATION


On the cover: Richard VanderMeulen photographed the Thorp T-18 in Torrance, California.

## Builder Spotlight



## Shop Talk



## Designer's Notebook



## Exploring



## Kit Bits

# AROUND the Patch

BY MARC COOK

## Surviving N30KP's *first* annual.

Yes, I know it's called a condition inspection. But it says something of my first "annual" that I won't have to take a bunch of pages to bore you with the gory details of the big open-up following a year of flying my Glastar Sportsman 2+2. One page will do the deed.

So, what did I find? Well, to start: Taking the airplane apart is often the hardest part of the job. Case in point. You may recall from the paint part of the 18-Day Sportsman saga that all the wing access panels were in place for the painting. Each screw was practically drowned in white paint, making subsequent removal excruciating. I tried every trick I know—super-sharp bits, a quick whack with a hammer, so-called "easy-out" bits—to salvage the screw heads to no avail. Removing them by drilling is not exactly efficient, but it's just the start of the fun. Then you have to remove the shank of the screw. In the end, I drilled the rivets out of 27 nutplates and replaced the lot. I got the process down to about 5 minutes per, which was more time efficient than trying to extract the screws by other means. It bears repeating: Don't let the shop paint over the access panels in place with the screws. Ever!

One broken terminal, coming right up.

Amid general tidying-up, I checked on a recent repair. We'd connected my B&C 60-amp with a $^5/_{16}$-inch terminal. Unfortunately, the alternator has a 6mm stud; $^5/_{16}$ is nearly 8mm. The original terminal had fractured. I noticed taxiing in after a night flight that the alternator wasn't staying on line—always be aware of changes, even small ones. Thankfully, uber supply house McMaster-Carr had the proper terminal.

New finds included three rivets on the spinner backing plate reinforcements that had lost their heads; new, one-size-larger rivets were installed. I checked the track of the prop and the alignment of the spinner, and they were fine. Ted Setzer, who works in the Glasair Aviation Customer Assembly Center, said that broken rivets there is not completely unheard of. I'll keep an eye on this one.

Next up was a slightly worrying surprise: One of the Swagelok fittings from the right main tank to the fuel selector was weeping, enough to leave a sticky stain on the floor below the console. After draining the tank—this connector is between the tank and selector—I discovered that the tube had apparently pulled out slightly during the original build, leaving a too-narrow swage. (The Swagelok fitting makes its own swage on the tube, but that tube must be fully seated in the fitting or it will leak.) Fortunately, there was enough line in the airplane to cut off the end cleanly and install a new Swagelok. Problem solved, but I'll make the first few flights after inspection with the top off the console just to keep an eye on it.

The final item of repair concerned the brakes. I'd noticed throughout the summer that the left Matco master cylinder would start showing bubbles in the line from the reservoir, no matter how thoroughly I bled the system. The pedal was firm and the Grove brakes worked great.

Suspecting air was getting into the master cylinder from the end seals, I replaced them: no good. So I replaced the master cylinder assembly and did something I'd been meaning to do all summer—replace the clear firewall-mounted reservoir and its unsightly lines with a pair of slick Grove reservoirs mounted right to the master cylinders. (Fortunately, access to them is very good, else I would have left the system alone.) My big gripe with the original setup is that the reservoir lines went from the cylinders down to the floor and then up to the reservoir. Any air would be trapped in that loop and never be allowed to escape through the reservoir. Bad deal, in my view. Now the brakes are perfect, the aft side of the firewall is cleaner, and if the master cylinder is still admitting air into the reservoir fitting, I can't see it and so don't care.

Before I could get down on the floor to bleed the brakes, I took the opportunity to fix something that's been bothering me almost since Day 1. We'd fitted the main wheelpants tightly around the brake calipers, so that you must carefully spread the rear half out and down to remove it. (Without removing the calipers first, of course.) Well, this was just dumb, flat dumb. So I removed the lower section, reinforced the inside of the now-cantilevered inside-front section of the pant, and gave myself 2-minute access to the brakes. Theoretically better ways to do things inevitably lose to easy maintenance. At least once a year. ±

*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.*



*Photo: Marc Cook*


## Yes, there are other glass cockpit displays for kitbuilts.

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*Garmin G900X packages are available for all new 4-place Lancair piston models, as well as all Van's RV series products configured for 2-across seating. For a list of approved avionics dealers, visit Garmin's website.

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# CONTRIBUTORS

**STEIN BRUCH**

For the third installment of "All About Avionics," Stein-Air founder Stein Bruch takes us through his recommendations on backup flight instruments for EFIS-equipped aircraft. Just when you thought your life was getting simpler... Actually, his philosophy is sound: You want sensible backups in case your shiny new computer—that's what an EFIS is, you know—shuts down at the worst possible time. His story begins on Page 42.

**RICK LINDSTROM**

Longtime contributor Rick Lindstrom comes out of hibernation with a vengeance this issue, authoring two stories: the initial installment of his building-a-Zenith odyssey and a hugely useful discourse on noise-reduction strategies for small aircraft. Rick wanted a one-of-a-kind airplane, and in many ways his painted-and-polished, Corvair-powered 601 XL is it. Watch for the rest of the story this year. Volume 1 begins on Page 16. "Soundproofing Tactics" starts on Page 24.

**BRIEN SEELEY**

You may remember Dr. Seeley from endeavors such as the CAFE Foundation's "You're Not As Fast As You Say You Are" flight reviews that put science in front of subjectification and "The Barograph That Ate Cincinnati." (OK, we're making that last part up.) Brien brings us the first episode of eCFI, an interesting example of combining available computing and control technologies to the problem of pilots doing stupid things when their flight instructors are watching someone else. This story starts on Page 31.


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KITPLANES® (ISSN 0891-1851) is published monthly by Aviation Publishing Group, LLC, an affiliate of Belvoir Publications, 800 Connecticut Avenue, Norwalk, CT 06854-1631, Robert Englander, Chairman and CEO; Timothy H. Cole, Exec. Vice Pres./Editorial Director; Philip L. Penny, COO; Greg King, Exec. Vice Pres./Marketing Dir.; Marvin J. Cweibel, Senior Vice Pres., Marketing Operations; Ron Goldberg, CFO; Tom Canfield, Vice Pres., Circulation; Michael N. Pollett, Sr. Vice Pres., General Counsel.





Subscriptions: One year (12 issues) is $29.95 U.S. $41.95 in U.S. funds in Canada, includes GST. $41.95 in U.S. funds for Foreign Surface Mail or $57.95 in U.S. funds for Foreign Air Mail. Single copy price $4.99 U.S., $5.99 Canadian.
POSTMASTER: Please send address changes and subscription inquiries to:
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# LETTERS

EDITORIAL@KITPLANES.COM

## Power to the Machinist

As a toolmaker/machine builder and CNC machine shop owner, I thoroughly enjoyed your first Home Machinist article. I, too, have a home shop that I use for wood and metal working. I have found, over 35 years in the business, that a Bridgeport type vertical milling machine is the most versatile machine one can own. With more and more machine work being done on CNC machines, Bridgeport type machines are readily available on eBay at a reasonable cost, $500 to $4000. Many are equipped with full accessories i.e. DRO (digital read out) power feeds and vises. Most of these machines were manufactured with three-phase, 230/460-volt AC electric motors and are not compatible with 230-volt AC single phase residential power. I solved this problem by powering the three-phase motor through a VFD (variable frequency drive) that converts 230 single phase to 230 three phase and provides motor speed and direction control. I would be glad to share my experience.

STEVE ARBIZZANI

## Bamboo and Visqueen?

Let me say amen to Paul Lund's comments in the April issue. Please consider giving more attention to the lower cost homebuilts. I could relate much better to the latest efforts of the "bamboo-and-visqueen" set than the fellow who is trying to pick a color scheme for his new $200,000 Lancair.

FRED WILHELM

## Avionics Tips

Great timing on your subject of avionics. I'm building a Mustang II. All of the flying will be daytime VFR. I would like to make a cross country trip of 500 n.m. maybe twice a year. I plan to use a Dynon FlightDEK-180 for simplicity, weight and money savings. My question to you is: Will you be covering the routing of wiring? What type wire, what type connectors, etc. Also of interest, since this is my first build, are the same questions as they relate to com radio, antennas, transponder, nav light systems, etc.

BOYCE RAMPEY

*Good news for you, Boyce. We'll be covering all those subjects in this series, and have some information on lighting in this very issue.—Ed.* +

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## Updateable - *Lifetime free updates*

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## Connectable - *Share displays*

Connect your Dynon instruments together with the Dynon Smart Avionics Bus (DSAB) and share display pages so that any screen can be displayed on any instrument whenever desired.

# WHAT'S NEW?

## Bright Screen Option

Dynon now offers an 800 nit bright screen option for its EFIS-D100, EMS-D120 and FlightDEK-D180. The enhanced sunlight readability, 854 x 480 resolution and night dimming capability deliver an impressive view no matter how you look at it.

## DG & HSI Navigation Pages

Dynon's stabilized magnetic heading information can now be displayed in DG format. Connect an external GPS to overlay an HSI with GPS-based CDI information. Connect a Garmin SL30 nav/comm radio and you get both CDI and glideslope information.

When using the EFIS's magnetic compass alone.

When connected to a GPS with NMEA 0183 output or the Garmin GPS 430/530.

When connected to the Garmin SL30 Nav/Comm Radio.

## Winds Aloft with Crosswinds

When connected to an external GPS, Dynon EFIS-based products calculate winds aloft to evaluate best cruising altitudes. Additionally, discrete crosswind component information helps you fly safe approaches.

## Shock Cooling & Span Alarms

All EMS-based instruments now offer CHT shock cooling and CHT span alarms to protect from damaging the engine.

## Flap & Trim Indicators

Dynon has added flap and trim indications to all EMS-based products. They can be selected and arranged in a location of the user's choosing.

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QC Avionix offers a small (2x3x1.5-inch), lightweight (1.5 ounce) two-stage automatic float battery charger designed specifically for 12V lead acid rechargeable batteries. The charger delivers up to 0.5 amps, and upon reaching full charge automatically switches to float mode, which maintains the battery at full charge without overcharging. The charger can be left connected indefinitely to any 12V battery that can handle float voltages of 2.20-2.22V per cell without damage to either the battery or the charger. Two indicator lights show battery status: red for charging and green for float mode. Reversing or shorting the battery connections will not harm the charger. Four-foot battery cables are included.

The price is $69.95. A 10-foot extension cable is $24.95. For more information, contact QC Avionix at 978/897-3891, or visit the web site at www.qcavionix.com. A direct link can be found at www.kitplanes.com.

## Anywhere Map Update

Anywhere Map announced a new version of its PDA software, Version 1.9. This release contains nearly 40 enhancements and several new features, the company says. Among them is support for the Zaon XRX Traffic Scope.

In an ongoing effort to be responsive to its market, and with the help of an eight-person "beta team" of customers who use the product, development of the new version of Anywhere Map stayed true to its goal of improved flight management and safety. The company's web site offers a complete list of enhancements, but they include better weather status and reporting, more complete one-tap flight-plan data, and better "painting" of military ops areas. The company is committed to continually improving the product for the end user, says Tom Reed, vice president of operations.

An annual subscription is $95. For more information, call 800/292-1160, or visit www.anywheremap.com. A direct link can be found at www.kitplanes.com.

## New from ASA

Aviation Supplies & Academics has added new titles to its inventory of manuals and other educational media, among them *The Pilot's Manual: Ground School*, *The Pilot's Manual: Instrument Flying*, *Dictionary of Aeronautical Terms*, and the *Rotax 912 Engine Introduction* DVD.

The Ground School manual (PM-2B) walks students through all they need to know to pass both the Private and Commercial FAA Knowledge exams, including rules, procedures, aeronautical decision-making, risk management, etc.

The *Instrument Flying* manual (PM-3B) uses building-block techniques drawn from experienced pilots to teach pilots how to fly IFR. First comes the groundwork, followed by knowledge about departure, en route, terminal and approach procedures. All of the tasks from the FAA's Practical Test Standards are covered, ASA says.

The *Dictionary of Aeronautical Terms* (4th Ed.) explains more than 10,000 terms and includes nearly 500 illustrations. Terms have been gathered from the FAA, AIM, and from other glossaries and manuals. An acronym listing and Morse Code chart are extras.

The *Rotax 912* DVD offers an overview of the engine's basic components, fluids, checking and changing oil, selecting proper filters, coolant options, electrical system, cold weather ops, dual carb synchronization and idle speed, prolonging engine life and reducing maintenance costs.

Prices are: *Ground School* or *Instrument Flying* ($59.95 each); *Dictionary* ($19.95), *Rotax 912* DVD ($49.95). For more information, call 800/426-8338 or visit www.asa2fly.com. Find a direct link at www.kitplanes.com.


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N3200

FLIGHT REVIEW

# CROOKED WING, STRAIGHT SHOOTER

## John Thorp's all-metal T-18 remains a viable plansbuilt design.

BY MARC COOK

Forty-five years ago, while that lanky VanGrunsven boy was edging toward commercial greatness by modifying a Stits Playboy, one John Thorp was setting the homebuilt category to chattering. His all-metal two-placer, called the T-18, was touted as easier to build and lighter than the dominant wood designs of the day.

Moreover, it featured something slightly outrageous: match-hole tooling, which located sheet-metal parts by way of aligning holes, thus eliminating (or at least greatly reducing) the need for jigs. VanGrunsven himself admits that the T-18 was influential to him, as was watching a Midget Mustang come together.

The designation of the T-18 suggests, accurately, that it was Thorp's eighteenth design, some of which were produced while others were unrealized design studies. Cataloguers show 32 designs and derivatives between the early 1930s and the mid 1970s

Among those designs you might remember are the Piper Cherokee—hmmm, we've vaguely heard of that one—and the Sky Skooter, which has evolved into the Indus T-211 LSA. A graduate of Boeing's School of Aeronautics, Thorp worked for Lockheed and is credited with the preliminary design of the P2V Neptune. The airplane before the T-18 would become the certified Wing Derringer, a two-place, twin-engine speedster that has been produced in amazingly small numbers considering its over-the-top cool factor.

### Simpler Is Better

Thorp's design philosophy, at least for the smaller craft, was that simplicity and low weight were key. The Piper Cherokee benefited from this ideology with a massively reduced parts count compared with the tube-and-fabric Pacer/Tri-Pacer series that was Piper's mainstay before, and it was light, simple to produce and, as a result, profitable. The greatness of this basic design is evident in its ability to grow from a modest four-place fixed-gear single to a six-place retractable twin.

That the T-18 and Cherokee are related is hardly debatable. Constant-chord wings mean straightforward structure underneath and increased parts commonality. A stabilator promises lower drag and less weight; it can be more effective than a horizontal stab/elevator combo, but requires greater care in development. And in a world dominated by stretched-skin aluminum or sleek, compound-curve composites, the T-18's angular empennage can be seen for what it was: an attempt to make construction possible with a minimum of special tools and skills.

A successful plansbuilt design for many years, the T-18 evolved significantly. The T-18C was modified with a folding (called "convertible") wing designed by Lu Sunderland, who worked with Thorp for many years. A wide-body version, called the T-18CW, enjoyed an extra 2 inches of cabin width and 5 inches of fuselage length. There was also a version with the wide fuselage and the non-convertible wing with a new Sunderland airfoil. Finally, there was the S-18, for which kits are still available through Classic Sport Aircraft. (Clas-

*Photos: Richard VanderMeulen*

sic Sport is also developing a trigear version.)

## Power to the People

In the day, Thorp designed the T-18 to carry a Lycoming O-290-G, a ground-power unit that was coming into the used market in great numbers. It could be modified into an O-290-D, making 125 horsepower. Today, those are rare engines and most T-18s being built (and many flying examples) use the O-320 and O-360 engines. The O-320 is literally a good fit because it has the same footprint as the 290 even if the accessory layout and other details are different. According to data posted on the T18.net (a Thorp enthusiast web site), the design can use anything from the 115-hp O-235 to a 180-hp O-360 with a constant-speed prop.

The airplane pictured here, owned by Barry Jay, sports a low-compression O-320 making 150 hp and spinning a fixed-pitch prop. Jay's airplane is an early T-18, built in the 1970s—likely started not far into the 1960s—and registered in 1971. As such, it's of the narrow-fuselage variety with the cranked wings but no folding mechanism. Humans of modern size will immediately see why the T-18 morphed into the widened S-18; two average-size males are closely elbow-to-elbow once seated and only after a careful dance to get onto the wing, past the close-fitting canopy, and down into the seats. It looks like a mating ritual from Mutual of Omaha's *Wild Kingdom*.

The diminutive interior dimensions assert themselves once one is properly ensconced. The windscreen seems as a gun slit. The control stick tops just above the thigh, and the rudder pedals require no stretch at all for a 5-foot-9 pilot. After a brief tussle to free headset cords and to establish a pecking order—much as you would in a Boeing's coach-class center seat—it's time to fire up. Jay's O-320 kicks off with a few strokes of the throttle, and the simple systems are quickly brought on line.

Jay was quick to get moving, grabbing the ATIS and moving inside the uncontrolled ramp toward the active, because the T-18 as configured is not overly endowed with cooling capacity. It's actually fine in the air, but the convoluted air path—it comes in high, drops through the cylinder fins and then back up the outer edges to exit alongside the fuselage—means ground cooling is marginal. Best to program the GPS before you start. It's better for the passengers, of course, with the canopy back, elbow on the ledge, enjoying the breeze; the wingtip seems close enough to touch.

The "cranked" wing outer panels improve dihedral effect.

## Hey-ho, Let's Go

A brief and normal runup is followed by taking the active. With power applied, the T-18 accelerates briskly, and it feels just slightly less energetic than my own 215-hp Glastar Sportsman, which is as expected. The Thorp has a slightly better power-to-weight ratio but lacks a constant-speed prop; the O-320 is turning an expected 2250 rpm during the take-off roll.

The tail comes up smartly at 40 mph IAS, and Jay does a slight rudder dance to compensate for the quartering tailwind—an artifact of Torrance wanting to use Runway 29 at just about anything short of a big east wind, or so it seems. Count a few more seconds and by 70 mph IAS, we're off. As you sit back there in the runup pad considering the long proboscis out the windshield, you probably don't figure it to be such a good aid for tracking the white line, but it is: Any movement of the nose across the runway is immediately evident, and it seems

Engine access is simplified by removable cowling cheeks. In this case, they're held by quarter-turn fasteners. Owner Barry Jay keeps his Thorp neat.

that a pilot with a reasonable skill set should at least recognize when the airplane is no longer aligned with the runway centerline. (Of course, what is then done with that information is an open question.)

I'm handed the airplane soon after departure and begin to delight in the T-18's handling. While the airplane may seem stubby and a bit strangely proportioned to those unfamiliar with it, the handling betrays no such quirks. It's utterly conventional, in fact, with a strong tendency to maintain trimmed airspeed, little adverse yaw and nicely harmonized control pressures. You need not grab the stick with your whole fist—good thing, as that might not be possible if you have running or cycling in your physical makeup—nor do you need to pinch it lightly between thumb and forefinger. It's just right, in fact. Modest control pressures get the job done the first time.

With just 10.7 pounds of airplane for every horse to lift—OK, let's call it closer to 12 given that the fixed-pitch prop limits climb rpm and therefore horsepower—it's no wonder the T-18 climbs strongly. Our initial ascent at 110 mph IAS was 1500 fpm, with nearly 2000 available at the best-rate speed near 90 mph IAS. Holding 110 mph with an OAT in the low 70s, the hottest cylinder comes up to nearly 410°, so we shallow the climb a bit at 120 mph; even so, we're maintaining better than 1000 fpm. I calculated our takeoff weight as

1530 pounds, some 70 under maximum gross weight, so a true all-up climb rate would be lower, but not by a lot.

At the top of the climb, reach forward along the center tunnel for the big knurled wheel to reset pitch trim. It's geared perfectly for fine adjustments, which means you'll be swiping at it a bit as the little Thorp accelerates. To compensate for any roll asymmetry, tweak a small knob near the flap handle. It slightly extends or retracts one flap.

## Doing the Cruise

The Lycoming winds up to 2400 rpm easily at 5500 feet MSL on 24 inches—just under 70% power. Jay's airplane does not have a fuel-flow meter, but the O-320 should be consuming around 7.5 gph at this power setting. With the 27-gallon header tank—the only one in this airplane, and the standard T-18 configuration—that's 3.6 hours absolute. Incidentally, the airplane weighs 1060 pounds empty, so with that tank full, it'll have a 382-pound payload. Two skinny types might be able to use the whole 80 pounds of allowable baggage behind the seats.

After becoming accustomed to the low nose attitude in cruise—something this pilot had to learn, at least initially—the T-18 accelerated to an indicated 146 mph. A two-way speed run at 5500 feet MSL yielded 155 mph TAS (135 KTAS). Other Thorp owners have seen cruise speeds near 180 mph TAS

(156 KTAS) with the 180-hp engine, and it seems reasonable that the 150-hp version could run 160-165 mph at maximum-cruise power. (The usual caveats apply about prop choice and pitch, airframe cleanliness, engine condition and leaning tactics.)

## That's What We're Talkin' About!

Some designers and aircraft owners go on and on about cruise performance—raw speed or efficiency or how their airplanes shrink the world, and that's fine. But the Thorp owner is apt to be more like Jay, enjoying the decent speed but relishing the airplane's handling qualities. We alluded to this before, but it bears amplification: This is one sweet airplane. With those stubby wings, you'd expect little adverse yaw, and in this case you'd be right. Guide the stick left and right, and the nose follows faith-

## THORP T-18

| | |
|---|---|
| Used price | $20,000 - $50,000 |
| Kit price (S-18) | $18,500 |
| Estimated completed price | $30,000 - $50,000 |
| Estimated build time | 2200 hours |
| Number flying (at press time) | 400 (T-18 and S-18) |
| Powerplant | Lycoming O-320, 150 hp @ 2700 rpm |
| Propeller | McCauley fixed-pitch, two-blade |
| Powerplant options | 115 - 180 hp |

### AIRFRAME

| | |
|---|---|
| Wingspan | 20 ft 10 in |
| Wing loading | 18.6 lb/sq ft |
| Fuel capacity | 27 gal |
| Maximum gross weight | 1600 lb |
| Typical empty weight | 1050 lb |
| Typical useful load | 550 lb |
| Full-fuel payload | 392 lb |
| Seating capacity | 2 |
| Cabin width | 38 in |
| Baggage capacity | 80 lb |

### PERFORMANCE

| | |
|---|---|
| Cruise speed | 165 mph (143 kt) TAS<br>7000 ft @ 75% of max-continuous, 8.4 gph |
| Maximum rate of climb | 1500 fpm |
| Stall speed (landing configuration) | 59 mph (51 kt) IAS |
| Stall speed (clean) | 68 mph (59 kt) IAS |

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



1. Barry Jay's T-18, built in the early 1970s, has been the beneficiary of a panel upgrade. 2. Manual flaps are operated by this Johnson bar. The small knob left and below the base of the bar slightly extends or retracts one flap for roll trim. 3. The T-18's manual pitch trim is operated by this metal wheel well forward on the central tunnel. 4. John Thorp's trademark stabilator is used on the T-18, fitted with two trimtabs. 5. Side-exit cowling cleans up the belly, and gives the pilot firsthand notice of an oil leak.



fully. In fact, it's hard to resist the temptation to overcompensate in pitch for the turn, but just a touch of back stick will hold altitude. Moreover, the T-18 has commendably good pitch stability and stick force in that axis that seem just right. It's stable and predictable, willing to return to trimmed airspeed quickly and elegantly—not sloppy like a Cherokee or super aggressively as, say, a Cessna Centurion. In the Van's universe, the T-18 is closer to the RV-9 than the RV-6, 7 or 8 series. Thorp's airplanes are highly regarded for their handling, and the T-18 does nothing to diminish that reputation.

Stalls in Experimental aircraft can be all over the map, but the Thorp is straightforward. The worst that can be said is that it gives very little warning—a slight burble that might be mistaken for an engine harmonic. At least that's the case without stall strips. Thorp owners have tried stall strips on the wing, and report that they improve stall warning.

Thanks to generous airspeed limits—$V_{NE}$ is 214 mph, $V_A$ is 160—you can bring the T-18 downhill at a good clip without running into the yellow arc. Landings work well either three-point or on the mains first, but be careful of sink rate. The T-18 will come down in a hurry when power-off and slow, and the tubular-steel gear—a big inverted U bolted to the engine mount at the firewall—is fairly unforgiving. Touch down with much sink rate, and you'll get to log an extra landing or two before it settles down. Jay says he lands three point about half the time.

## Is It for You?

There is a reasonably good size fleet of used T-18s in the world. (A great buying-used checklist can be found at www.t18.net.) And the current S-18 kit can be built in approximately 2200 hours. While the Thorp doesn't have the avalanche of popular support of, say, the RV series, it's a fine alternative for someone who wants a good-performing two-seater that elicits a "Hey, that's cool, what is it?" response instead of, "Oh, another RV." You know who you are. ±

*For more information on the S-18, contact Classic Sport Aircraft at 559/539-2755. Visit the company's web site at www.classicsportaircraft.com. A direct link to the company's site can be found at www.kitplanes.com.*

Part 1

# A Sign of the Zodiac

## Another of our own takes tool in hand to create a dream machine.

BY RICK LINDSTROM

In the early morning of November 10, 2006, a certain Corvair-powered Zenith Zodiac 601 XL—that would be mine—flew for the very first time in the still morning air from Florida's Massey Ranch Airpark. Test-piloted by FlyCorvair.com's Gus Warren, N42KP lifted off at 7:32 EST, made a single left-hand circuit, and then lightly touched down and rolled out. After taxiing back to the hangar and shutting down, Warren reported the first flight as mostly uneventful, with the only new problems being an abnormally low fuel pressure indication and a pessimistic EFIS display that continually thought the aircraft was in a descending right turn. The plane itself, along with its converted and zero-time 100-horsepower Corvair engine, performed flawlessly.

It's always thrilling to see a brand new airplane make its very first leap into the air, even when there are a few bugs still to be exterminated. In this case, the same leading-edge instrumentation that was supposed to accurately report 42KP's engine parameters and flight characteristics seemed to be making halfhearted attempts under actual conditions. It was, once again, time to roll up the sleeves (yes, Florida *does* get a mite chilly in November) and track down the source of the discrepancies. That legendary and elusive perfect first flight, with no problems whatsoever, would have to wait for another aircraft project in another time.

### Not So Sudden Urges

I doubt many builders suddenly wake up on some random morning and exclaim "Huzzah! For I must certainly build an aeroplane!" I didn't, either. But the urge had been gnawing at me for quite a few years, and it was only a matter of time until I took the plunge personal-like. As my KITPLANES® writing assignments have taken me further into the world of aircraft instrumentation and avionics, having my own Experimental/Amateur-Built aircraft to use as a research vehicle certainly seemed like too good of an excuse to put off my own airplane project any longer.


This may look like a big crate on a flatbed trailer, but it's really the first Zenith Zodiac 601 XL fast-build kit. Add a builder, wait a bit, and voila! Your very own flying machine appears.

Project lead Gus Warren (front) and Dave "The Bear" Vargesko get right to removing all the neat stuff packed in and around the fuselage. The flat skins were ultimately discovered underneath.

Zenith's people say the fuselage comes fully assembled in the fast-build kit, and they're not kidding. Even the baggage shelf and center console supports are fully riveted in place.

Armed with a sufficient number of rationalizations to start my own project, I commenced to give serious thought to finding an affordable kit that someone with limited building experience could assemble and fly in a short amount of time. Although there are many kits that fit this description to a tee, there was another factor that would narrow the airframe search considerably.

## What's Good for General Motors

It's no surprise to anyone who knows me personally that I have never been accused of being normal. So instead of taking the usual route of choosing an airplane kit and then searching for a suitable engine, I did it the other way around.

Having owned and maintained (and financially supported) a fair number of certified aircraft and their engines, one of the most attractive aspects of building an Experimental airplane was the option of using an automotive conversion powerplant. Not straying too far off the aeromotive design reservation, the best of all worlds would be an inexpensive air-cooled auto engine that didn't need a propeller speed reduction unit (PSRU) to drive the prop. With these two requirements, the number of eligible engines drops sharply, and the two likely contenders came down to either a Volkswagen or a Corvair conversion.

Zenith has taken the opportunity to beef up the engine side of the firewall with the fast-build kit, with additional support and bracing for the nosegear fully in place.

Right about the time I was beginning to compare the two designs, I was given an assignment to cover the work that William Wynne (aka "The Corvair Authority") was doing at his hangar in Florida. After meeting with Wynne at the next annual EAA convention, I was impressed by the depth and breadth of his experience in the Corvair conversion world, and his personal zeal for the engine itself. After interviewing quite a few pilots who had just flown a wide variety of aircraft types into that same convention behind Corvair power, I knew that I had stumbled upon an affordable, reliable, air-cooled, direct-drive powerplant that an average human could successfully build under Wynne's guidance. Which, of course, included me.

Having decided upon the engine up front narrowed the airframe search considerably, but I still had a wide selection of kits from which to choose. Obviously, the larger and faster designs were out of the question given the power available from the typical 100-hp Corvair. And because it was likely that a small two-seater was now in my future, an LSA compliant design seemed like a good idea as an investment for some future time should the process of renewing

*Photos: Rick Lindstrom*

my medical certificate no longer be the usual biennial slam dunk. A metal airplane seemed like a good idea, and it had to be easy to build because I still have a "real" job, a wife, kids, two dogs and a few other time commitments.

## Beauty Airplane, Eh?

After agonizing over the final decision a bit, I decided to call Murphy Aircraft in Chilliwack, British Columbia, and order a Rebel kit. I made my intentions known to them, and we began the usual dialog regarding availability, pricing, options, delivery dates, support, motor mount and cowling design assistance, and the rest of the usual things that interrupt your sleep when considering mating an automotive conversion engine to a kit airframe for the first time. I began to

Even the rudder pedals, master brake cylinders, and mounts for both are pre-installed in the fast-build version. The instrument panel and top skin are temporarily in place with a few blind rivets.

Zenith used every conceivable space available in the crate to ship the parts, and after removal, the pile grew to impressive proportions very quickly.

Smaller parts and hardware are packed within a few cardboard boxes, but it's a good idea to open them up and sift through the contents completely before setting to work.

Warren admires the finish work on a couple of control linkage components. In his mind, he's already got them installed and is working on final rigging.

lose a fair amount of that sleep when I really started thinking about what is involved in blazing such new trails.

In a sudden and unexpected fit of common sense, I recalled that Wynne had chosen a Zenith Zodiac 601 XL taildragger kit as his own flying test bed for the Corvair. Wynne's team in the Fly Corvair hangar had completed their airplane in roughly 90 days from start to finish, and the Corvair/Zodiac combination had proved to be a good matchup, indeed. So I asked myself, why was I heading off in a completely different direction from one that already met every one of my requirements? The answer was obvious, including a self-admonition to "quit being stupid already."

As my airplane project began to move from purely theoretical to reality, and real money was on the verge of being spent, I bounced the wisdom of my new final decision off Wynne and the folks at Zenith. Chris Heintz, chief designer and patriarch of the Zenith (an anagram for Heintz) clan, thought the Corvair/601 combination was a very good choice. Zenith head of sales Sebastien Heintz then offered the opportunity to purchase the very first fast-build 601 XL kit being manufactured, and I was completely sold on the combination.

Wynne, having just gone through the 601 XL build process 100 flight hours prior with his airplane, fully supported the concept. Furthermore, he graciously floated the idea of building my airplane in Florida at his shop, where the equipment and expertise would be in great abundance compared to a solo effort in my meager T-hangar in California.

That did it. Although it meant a regular series of cross-country airline commutes to build my own airplane, the myriad benefits of having a fully equipped shop, right where the engine would be built, greatly outweighed the extra cost of several round-trip airline tickets. Because I would be building the first fast-build 601 kit, and Wynne and crew had spent just under three months

on their own 601 XL taildragger, I didn't anticipate racking up too many frequent flyer miles on Delta. With building excitement and just a bit of miserly regret, I sat down and wrote a couple of sizable deposit checks for an engine and airframe kit in the fall of 2005.

As I was getting the first fast-build 601 XL kit, it would be a while before the big box would actually appear in front of FlyCorvair.com's hangar at Massey Ranch Airpark (X51). This turned out to be a good thing, as eager as I was to start building. A later delivery gave me the opportunity to think through any changes or options I might want to include in the initial build process, and as it turned out, I ended up with more than initially planned.

Sitting upright on a pair of padded sawhorses, this Zodiac fast-build fuselage exhibited very few dings, dimples or hangar rash.

## Christmas in February

At around high noon on February 7, 2006, Russ Lepre from the local Zenith distributor, Air Crafters, pulled up in front of the hangar with a large rectangular wood crate strapped down in the center of a vehicle hauler; my Zodiac had finally arrived. After some box wrangling with a borrowed forklift, we had the box inside the hangar and were all dying of curiosity to see exactly what a fast-build kit looked like. Our mood was akin to kids on Christmas Eve—we were all dancing around in glorious impatience, waiting for the first panel of the crate to come open.

After the top was removed, all we could see were somewhat mysterious white, foam-wrapped shapes that had been carefully nested in whatever space happened to accommodate each item's particular dimensions. After removing the sides and ends of the crate in concert with removing the rest of the contents, it was time to unwrap the main attraction, the fast-build fuselage. We carefully peeled the foam wrapping away from its bulk, and in doing so, discovered a cornucopia of small parts tucked in all of its various recesses. After the ones that

This line of rivets on the fuselage is indicative of the care given to the quality of Zenith's blind rivet construction. While not absolutely perfect, it's still pretty good.

William (The Corvair Authority) Wynne and Gus Warren use a length of angle iron and a C-clamp as a makeshift brace to support the maingear leg while holes are being drilled.

Although you don't absolutely need a drill press to build this kit, it does make work like this much quicker and easier. A second set of hands comes in handy occasionally as well.

were easily visible were liberated from the confines of the structure, two of us lifted the fuselage onto a padded pair of sawhorses and removed the balance of the foam padding.

Once the fuselage was fully exposed, naked to the world, we were collectively stunned silent. None of us was quite prepared for the fully finished structure, which not only met all of our expectations, but also exceeded them substantially. OK, a few of the top skins needed some final riveting, but other than that, the fuselage was already done. Period.

## Surprise, Surprise

I don't know exactly what kind of insanity grips people when a new aircraft kit first arrives, but we were all infected at this point. There was no orderly removal and precise cataloging of items from the crate. Rather, project leader Gus Warren had removed the paperwork and construction manual (on CD), and was booting it up on a Windows XP laptop. That left the usual gang of suspects at FlyCorvair, and me, to mimic kids under the Christmas tree, opening various white foam-wrapped packages with suitable "oohs" and "ahhs."

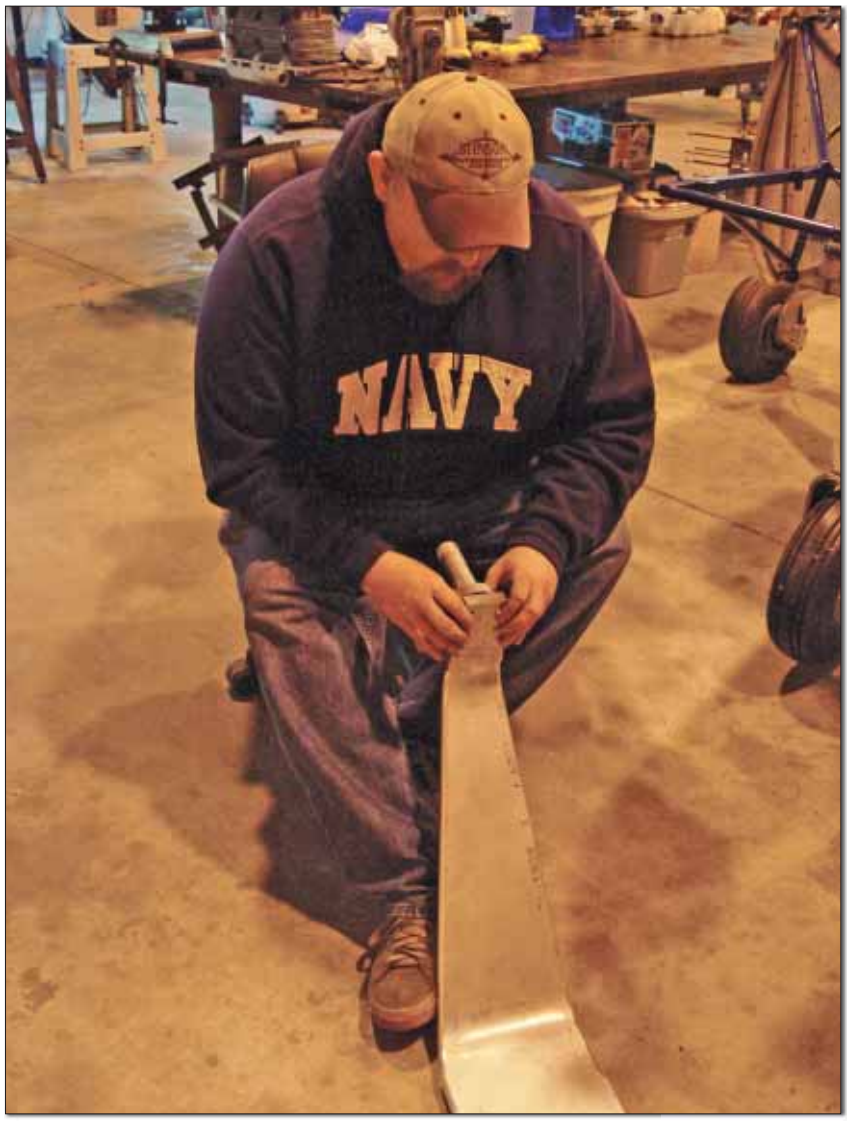
Finally, Gus opined that it would make sense to get the fuselage on its

The old saw about measuring twice and cutting once applies here, too. Messing up a major component like the gear leg assembly not only creates unwanted delays, but is expensive to remedy.

gear, no matter what sequence the construction manual suggested, so we could at least move it around the busy hangar. By that time, we had collected a huge pile of boxes and foam-wrapped items, with only a few easily identifiable. Although external content markings have now been greatly improved by Zenith, our pile of parts had no distinguishing marks to clue us in on the actual contents of each package. So we began the task of unwrapping and cataloging the parts that we'd need to put the fuselage on the gear, and sorting the rest into groups that would be needed later.

At the time, I found having to unwrap everything to figure out what it was a bit irritating. In retrospect, however, it turned out to be good thing, as we quickly knew if anything had been overlooked upon packing at the factory. Or so we thought. Some small nosegear axle bushings that were crucial to getting the fuselage to roll around were missing, so replacements were immediately fabricated on the spot. The advantage of building in a well-equipped shop became instantly apparent.

Of course, the missing bushings were finally discovered after new replacements had already been crafted, the package cleverly hidden inside a fuselage recess we had somehow overlooked. We later became more thorough in our quest for kit parts before calling Zenith customer support to gripe about missing stuff. This strategy saved us quite a few red-faced apologies when allegedly missing items miraculously appeared.




Warren dry fits an axle assembly to the gear leg to confirm proper alignment before any excess aluminum is trimmed off of the leg. An air-driven rotary rasp makes short work of this.

## Perfection! (Well, Almost)

That's not to say everything was sheer perfection after coming out of the crate. The dual control-stick option was missing, with the standard Y-stick in its place. The dual brake option was mostly there, with the second set of brake pedals mounted up, but the brake cylinders were AWOL. But overall, besides being incredibly well packed and protected, Zenith's first fast-build kit greatly exceeded our expectations for completeness and component quality.

Later, while building the complete fuselage structure, we would discover a few things that needed some correction along the way, despite the factory-complete nature of the kit. Because the whole amateur-built enterprise allowed by the FAA is solely dependent on the philosophy of "builder education," it was tempting to think of these few, slight discrepancies as intentionally planted irregularities to see if builders really were paying attention and learning anything.

But most likely these things are due to the human factor ever-present when a factory employs flesh-and-blood people to create aircraft kits. The first major lesson I learned is that a small dose of skepticism is required when working with a factory pre-built structure. It really doesn't take long to fully inspect the work that's been done before, and occasionally you'll find a mis-drilled hole or a piece of sheet metal that's slightly over or undersized. This may require another measurement, a bit of trimming, or rarely, a new part from the factory to set things right. Overall, though, the satisfaction gained from catching the rare anomaly greatly outweighs the extra effort to get things exactly right. And you're learning along the way.

## A Box o' Knives

The first lesson I learned from the kit was how incredibly sharp the edges of sheared sheet metal are, and I have a few small scars to prove it. After that first nick, I recalled the words of my metal shop teacher in middle school when he discussed the safety aspects of working with the shear. No kidding, you can't be cavalier about carefully handling all of those parts that will ultimately fly in tight formation as an airplane.

Once the metal part comes out of its protective foam or other packing, it's incumbent upon the builder to treat it like a steak knife without a handle. Until those sharp edges yield to rounding and dulling with a file or a deburring tool, care must be exercised in handling the metal, and even moving yourself around the factory-built major components that take great delight in occasionally biting the unwary. Band-Aids and hydrogen peroxide are highly recommended.

## Ready. Set. Build!

In our next installment, we'll cover the recommended tools used for the fast-build kit, and those shop items that make the process a lot easier. We'll discuss the options available in converting the Corvair engine for aviation use and report on getting the fuselage on its gear plus mounting the powerplant to the firewall. +

Soundproofing can make all the difference between arriving at your destination refreshed or distressed. Here, it seems to have done the trick.

# SOUNDING DOWN

## A small investment in time and materials yielded big dividends.

BY RICK LINDSTROM

With age comes the natural desire to eliminate as many irritants as possible from your life. And noise is one of the big ones, given its ability to induce fatigue and even irreversible hearing loss when one is overexposed for long periods of time. Continual high sound pressure levels will eventually diminish the comfort of the crew and passengers, and therein lies the rub.

When I began my primary flight training, most pilots simply endured loud cockpit noise. The Cessna 150 Aerobat I first flew rented for $5 per hour, the instructor got $4 and avgas sold for 56 cents per gallon. *If* the airplane had an intercom (and most didn't), you'd need to shell out well over a hundred bucks for a basic pair of uncomfortable headsets. For the same amount of money, I could buy more than 10 hours of dual. Besides, my instructor had no trouble communicating by shouting, with *really* important messages driven home by the occasional swat with a rolled-up chart.

Unfortunately, the cost of a flight hour has gotten a lot more expensive. But the good news is that the cost of a good basic pair of headsets is still about the same, with myriad styles available from a wide variety of manufacturers. There really isn't any good excuse not to own a decent headset, one that will protect your hearing, augment radio communications and also stave off any "correction smacks" from your instructor. (See the four-part headset review on www.kitplanes.com.)

OK, so you already have a good headset, one that provides 20 dB or better of noise attenuation. Isn't that enough? Maybe. Or maybe not. Light aircraft, especially the amateur-built variety, are notorious for high cockpit noise levels.

### Beyond the Ears

About the time I was learning basic flying skills, I was also working as an audio technician for a boutique stereo store in a Northern California college town. I was stunned to discover that we had a sizable customer base of the totally deaf, some of whom spent small fortunes on high-quality stereo gear. The owner of the store explained that these particular customers would "listen" to music by lying on the floor, with the soles of their bare feet very close to the speakers. The

These are all of the cut foam sections that were installed in the cabin aft of the firewall. Weight penalty? Less than 4 pounds.

This 3/8-inch foam-backed rubber mat works well on the cockpit floor under the crew's feet, but it is comparatively heavy at 1 pound per square foot.

You really don't need any power tools to efficiently cut the foam to fit. Measure, mark, cut, fit, trim and glue. The square was nearby and came in handy.

sound pressure from the speakers would stimulate the sensitive nerve endings on the bottom of their feet, allowing them to enjoy the music.

Other parts of the body are also susceptible to high sound pressure levels, especially bones in the skull. Anyone who's had the "pleasure" of witnessing a low-level, high-speed, military aircraft flyby (in full afterburner, of course) can confirm that the perceived sound permeates the entire body. Covering your ears helps, but the rest of your body just can't help but resonate along with that spectacular sound of freedom.

## One Man's Meat Is Another Man's Brussels Sprouts

You don't need to make the annual trek to Oshkosh to fully appreciate this acoustic phenomenon. There is an all-too-common example that many of us experience each day. This occurs when we share the road with someone who has transformed his or her automobile into a rolling boom box. If you've been accosted by one of these, you have probably guessed that sound is just another form of energy. In the range of human hearing, low bass frequencies take the most energy to reproduce. This explains why those cars are equipped with impressive woofer arrays, huge power amps and additional automotive batteries to provide the massive power required to support very high sound pressure levels of low-frequency energy.

The wing of the Zodiac 601 XL makes an acceptable impromptu workbench when covered with a moving blanket—as long as you're careful not to drop anything with sharp edges.

*Photos: Rick Lindstrom*

A good part of those high-pressure, low-frequency pulses become mechanical energy the moment they contact any of the body panels of the source vehicle. If you crack your window open, you'll hear the rattle of a car that's trying its best to come apart. The cumulative effect of this ongoing vibration is an assembly of automotive components being converted to a mere collection of ever-loosening parts. The conversion of acoustic energy to mechanical vibration is an easy one where a surface, whose dimension is a mathematic subset of the offending low frequency wavelength, resonates with every pulse. Truck lids and fenders come to mind.

The nature of physics also dictates that when sound waves meet an immovable object, the dissipated acoustic energy is converted to heat. In the practical world, the actual temperature increase is minor to the point of being for the most part unnoticeable.

## Aerial Considerations

Of course, light aircraft generally don't have huge woofers and amps as a source for noise. However, the physics are exactly the same, but with unmuffled exhaust systems and propeller pulses beating against the fuselage and windows providing the lion's share of unwanted acoustic energy. Figuring out how to best minimize the effect on the occupants of the airframe requires understanding what methods are usually employed when knocking down the sound pressure level (SPL) in any other noisy environment.

Where light aircraft are concerned, there are a couple of effective strategies in reducing cockpit noise: creating a sound barrier between the energy source and the cabin, and absorbing the sound once it enters the cabin. Using both methods in tandem is the most effective way of keeping as much sound as possible outside, and then dampening what manages to enter.

The soundproofing foam comes in 48-inch-wide rolls, from $^1/_8$ to 2 inches thick. This huge 20-foot roll had a shipping weight of only 15 pounds.

## How Can You Tell?

A handheld sound pressure level meter is a handy device for determining numerically how effective your soundproofing efforts are, and this is exactly what I used when I recently put the soundproofing theory to the test in my freshly completed Zodiac 601XL. Powered by a 110-horsepower Corvair automotive conversion that expels exhaust through twin unmuffled pipes, my all-metal 601 kit came with no factory soundproofing, typical of most light airplane kits. So the first order of business was to go fly a bit and see exactly how loud the 601 was with only the seat cushions and the pilot as sound-absorbing devices.

Since sound pressure is measured in decibels, it's helpful to review how these little guys work. A decibel (abbreviated "dB" and named after none other than Alexander Graham himself) is the smallest amount of sound level change the average human ear can detect. The threshold of human hearing is -60dB, and the eardrum will rupture right around 160dB. So there's a 220dB range of hearing to consider, from the 20dB whispers to 110dB front-row rock concerts and 140dB nearby jet engines. Just above the midpoint in this range, sound starts to be actually painful, but just pain itself isn't an accurate precursor of temporary or permanent hearing loss.

The "before" picture of the right cockpit wall with no insulation. The sound pressure level meter used for testing is shown in the foreground.

The "after" picture with half-inch foam insulation on the cockpit wall.

This vertical gap in the firewall allows for the rudder linkage to connect to the nosegear. It sealed up nicely with a bit of foam without impeding function.

Another interesting thing about the decibel scale is that it's not linear. To get a 10dB increase in sound pressure, the energy needed to achieve this also must increase by a factor of 10. For example, your home stereo will provide a good, listenable amount of sound on one watt or so, but to increase the sound by 10dB, you'll need 10 watts. If you want another 10dB increase, your power amp will now need to deliver 100 continuous watts. Conversely, getting a 10dB decrease in sound pressure, especially anywhere near the 100dB level typical in the cockpits of light aircraft, represents a huge decrease of acoustic energy.

## Hush, Little Zodiac

During the first flight to establish a "no soundproofing" baseline, I took sound pressure measurements during taxi at about 1100 rpm, during runup at 2000 rpm and during full-power takeoff near 3000 rpm. Like most light airplanes, the 601 turned in figures typical of metal designs that fly with 100-hp engines. The SPL during taxi was 90dB, 96 during runup and 103 during the takeoff and initial climb.

Back in the hangar, it was time to take the first stab at noise reduction. For this, I had two weapons provided by Bill Nash of Super Soundproofing

in San Marcos, California. When I first described this project to Nash, who has been in the aircraft soundproofing business for decades, he suggested two methods to attack the noise. They showed up in the hangar as a 4-foot-wide roll of half-inch closed cell vinyl nitrile foam, and a $^3/_8$-inch thick foam and rubber sandwich sheet, much heavier, but suitable for aircraft floors beneath your feet.

Both are FAA approved for use in aircraft, meeting the required burn resistance and also being immune from soaking up water- or petroleum-based fluids. The half-inch foam weighs in at 4 ounces per square foot, while the foam-backed rubber mat weighs just over a pound per square foot. With this in mind, and to keep the aircraft as light as possible, I decided to use the mat only where the heels of the crew would actually contact the cockpit floor.

Nash also suggested that the most effective way to vanquish the cockpit noise was to start with the cabin-side firewall surface, and work aft where the installed soundproofing would become progressively less effective the further it got from the source of the unwanted sound. Unfortunately, easy access to the cabin side of the firewall and the fuselage bottom just below was next to impossible, given that the aircraft was already assembled. First lesson learned: Think about soundproofing early on in the aircraft project.

To trim accurately to match the curves, the author found that merely pressing the foam against a sharp edge resulted in a temporary impression that remained long enough to make the cut.


Installing the foam on the engine side of the firewall took a lot of measuring and trimming to get around protrusions, but it was much simpler than trying to reach the cabin side.

The firewall foam installation in process.

The firewall installation is complete (below).

## I Love Low Tech

The easiest place to start the soundproofing was in the cabin, so that's where I began. Admittedly, it meant starting with sound absorption instead of sound attenuating strategies, but on the other hand, I could first see how effective cabin insulation alone would be. Installing the half-inch foam on the inside of the fuselage skins was as straightforward as it gets, and is almost impossible to screw up.

The vinyl nitrile soundproofing foam is wonderful material to work with. It cuts easily with a pair of shears or an electric knife, can be stretched or compacted slightly, and even holds an impression briefly when pushed up against an edge (which makes precise measuring with a tape unnecessary in many cases). If cut slightly oversize, it will hold itself in position between stringers or formers. It comes with a smooth side and a rough side, and it doesn't really matter which goes against the skin. Either side attached easily with a can of automotive 3M spray adhesive. It's available in various thicknesses between $^1/_8$ inch and 2 inches, so a really first-rate soundproofing job might require various sizes for maximum effectiveness with minimum weight penalty.

It took about four hours to measure, cut and install the cabin soundproofing using only the half-inch foam and a 34x5-inch strip of the heavy mat. Total weight penalty was 3.5 pounds, with the single piece of mat accounting for a full pound of that weight. Would cabin insulation alone have any noticeable effect on cockpit noise?

## Back in the Air, Back to the Hangar

The answer is "Yes, surprisingly so." At taxi, the drop in SPL was most noticeable, decreasing from 90dB to 85dB. Runup SPL dropped from 96 to 94dB, and takeoff/climb SPL dropped from 103dB to 101dB. Measurements recorded, I headed back to the barn.

The next sound-reducing strategy was to try blocking as much sound as possible from the engine and exhaust. Since the cabin side of the firewall was effectively out of reach for this test, the engine side

of the firewall came into play. Nash recommends two layers of at least half-inch foam, with a thin layer of aluminum, or even glue, between the two. Once again, the reality of the placement of many of the engine-side firewall mountings and accessories precluded a thick layer, so a single half-inch layer would have to suffice.

Again, the easy workability of the foam made cutting various shapes to go around protruding hoses and the like a snap. In cases where the foam was inadvertently cut significantly undersize, it didn't mean tossing the piece and starting over. A second filler piece could be cut in a few seconds and the edge glued to butt up against the original, with the only loss being a slightly visible seam.

After a few flights, the author decided to see how much cabin noise could be damped by treating the surfaces in the baggage compartment. The opposing, acoustically reflective surfaces responded well to a layer of half-inch foam.

After a few hours of cutting and gluing, and 1.5 pounds later, it was time to go fly again. Across the board, the SPL dropped only a single decibel with the single half-inch layer on the engine side. Another lesson learned: Listen to Nash when he recommends two layers separated by glue or foil, for a noticeable decrease in cockpit SPL.

## The Last Audible Gasp

The Zodiac 601 has a cavernous baggage compartment right behind the heads of the crew that closely resembles the inside of a giant cowbell. I couldn't help but wonder if insulating the insides of this acoustically reflective surface would help as dramatically as doing the inside of the cabin.

It took another few hours and also another 3 pounds of half-inch foam to insulate the top and sides of the baggage area, and off I went again to measure the results. This latest addition knocked another 5dB off the taxi SPL, down to 79dB. Runup SPL came down 2dB to 92, and takeoff/climb dropped out of the triple digits for the first time to 99dB.

## Some Sound Conclusions

If you still have easy access to the cabin side of the firewall, and the area of your fuselage nearest to the end of your exhaust pipes, now is the time to think seriously about soundproofing. It can be done after the fact, but may require partial airframe disassembly or some lengthy and uncomfortable contortions at the least.

Here's the left side of the firewall with a half inch of foam between the engine noise and the cabin. Sound from the exhaust system mostly enters the cabin from the fuselage bottom just aft of the firewall.

Think carefully about the weight penalty associated with increasing the thickness of the soundproofing material, saving the thickest and heaviest foam or multiple layers for the areas nearest the engine and prop. The total weight penalty can be minimized by graduating the thicknesses down the farther aft you go. And choosing something like a lightweight starter or alternator may completely offset the weight of soundproofing, although it will shift the c.g. aft some.

Was it worth the time and the 8 pounds? In my mind, absolutely. As Gus Warren, who has more than 400 hours of time in a similar 601 remarked, "Wow! It's much quieter than ours!" With results like that, who needs an SPL meter? ±

The author's Zodiac 601 XL is typical of all-metal kit aircraft, which are inherently noisy. In most cases, a few pounds of acoustic insulation go a long way toward creating a much nicer cabin environment.

# Come Fly with Me—the eCFI

## *Uh, yeah.* You could use one.

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

"Gauges are worthless unless you look at them"—*Lyle S. Powell Jr.*

This series of articles is a tribute to all Certificated Flight Instructors (CFIs), whose combined skills have led to an astonishing statistic: Student pilot flights with human CFIs aboard have a lower fatal accident rate than even air carriers. This fact suggests that an electronic CFI (eCFI) might dramatically improve the safety of personal aircraft. The following fictitious story illustrates the point.

John carefully buckled his 4-year-old grandson, Nate, into the child restraint system in the back seat of his homebuilt Experimental aircraft, Alpha Tango. John had promised Nate a visit to the Pacific Coast Air Museum in Santa Rosa, California, a short 130-mile flight from Merced. The weather that morning was gorgeous and, after takeoff, John climbed to 6500 feet and then flew direct on a heading of 289°.

As Alpha Tango settled into a 130-knot cruise in smooth air, John heard a voice in his headset say, "Tailwind is 30 knots. Advise reduce power." It was Alpha Tango itself, talking to John through an array of electronics that he had been developing for just over a year.

*Illustrations/Photos: Steve Karp, Brien Seeley*

Studies have shown that student flights with human flight instructors aboard have a lower accident fatality rate than even air carriers. The electronic equivalent can serve almost as a co-pilot, monitoring a variety of functions and parameters that might otherwise go unnoticed.

The system, nicknamed the "eCFI" by John's admiring hangar friends, was designed to serve as an electronic CFI like a second set of eyes and hands in the cockpit.

John was highly knowledgeable about electronics, having retired after 20 years of designing software that enabled sensors to talk to computers. His eCFI was modeled after the electronic assistant for personal air vehicles (PAVs) being explored at NASA. It included 11 pounds of sensors, software and servo controls that John had installed to operate Alpha Tango's side-stick control, flaps, avionics and throttle. A machinist friend had customized an electronic throttle servo from a late-model car, and the side-stick control was a duplicate of that in the Questair Venture. John's goal was to make Alpha Tango the safest plane in the sky.

A few minutes later, the eCFI issued a slightly gruff "Ah-humm" in John's headset. Surveying the cockpit, he realized that while pointing out the sights to Nate he had drifted 7° off course and climbed 200 feet. As he made these adjustments, the eCFI said, "Better. You are in command."

Although John knew his eCFI was no substitute for the real thing, he was delighted by the usefulness of the relatively simple system. By monitoring the flight and his piloting actions, it would alert him to possible hazards. John found this capability helpful for both in-flight awareness and post-flight review. He found himself wanting to add more and more sophisticated monitoring functions to the basic system. His latest project was programming the eCFI to initially present somewhat indirect prompts for minor problems, such as the sound "Ah-humm." John felt that this would enhance his own piloting skills while the eCFI maintained its vigilance as a backup that monitored his corrections. Little did John know how important his eCFI would be that Saturday with little Nate aboard.

As they flew over Mount Diablo, John heard the eCFI say, "John, blood oxygen slightly low." John's neighbor, a nurse anesthetist and pilot, had helped him integrate a pulse oxymeter into his eCFI. The oxymeter was unobtrusively clipped on his ear and continuously monitored his pulse and blood oxygen levels. His experience had convinced John to set 6500 feet as his personal maximum altitude without supplemental oxygen. Smoking a pack a day had taken a toll, and experience with the eCFI had convinced John that he needed to kick the habit.

## Emergency

As Alpha Tango flew over Bennett Valley just 12 miles from the Santa Rosa Airport, John felt himself losing his grip on the side stick. The weakness rapidly spread to his left leg. Within seconds, John was unconscious from a stroke. He slumped in his seat with shallow breathing, his hands folded in his lap and his legs curled under the seat. Like many children, little Nate, snug in the back seat, had fallen asleep and was unaware of his grandfather's collapse or that he was now in a pilotless aircraft. However, Alpha Tango's eCFI immediately sensed that something was very wrong.

Strain gauges on the control stick sensed that there was no longer any stick force being applied by the pilot. Other sensors detected that Alpha Tango had deviated from course in a steepening left bank, and that it had lost altitude and was increasing its airspeed in a dive. The wireless pulse oxymeter read John's pulse at just 44 beats per minute and blood oxygen saturation below 90% and falling. Programmed to recognize these ominous indications, the eCFI instantly launched the set of actions that John had also programmed and tested in case this very situation might occur.

## eCFI to the Rescue

First, the eCFI used its small but powerful actuators to clutch the underpinnings of the control stick and halt the steepening spiral. It simultaneously presented three buzzes per second with a voice prompt to John's headset that said, "Alert: Off-course, altitude loss" and applied a rumble strip type vibration to the side-stick controller, expecting John to wake up and correct the errant flight path. Sensing no response from John after 2 seconds, the eCFI assumed

full control, registering the situation as "possible pilot incapacitation." It continued to issue alerts to John to no avail. He remained unconscious and did not respond with the necessary double click on the stick button that would have signaled the eCFI to relax. Pilot incapacitation was now confirmed.

At this point, after re-trimming for straight and level flight, the eCFI used digital electronic commands to simultaneously perform multiple tasks:

1. It searched the GPS database for the nearest airports and gave priority to those that had rescue equipment and large runways. Santa Rosa (STS) was instantly identified as suitable, being within fuel range, 11 miles away.

2. It set the transponder to the Emergency Code of 7700.

3. It turned on special flashing landing lights to indicate to others that Alpha Tango was now essentially a UAV (unmanned air vehicle).

The eCFI then selected the STS tower radio frequency of 118.5 MHz, and used its voice synthesizer to report as John had programmed it for this eventuality. Programmed to identify the airport, Alpha Tango's position and predicament, and the runway with which it was aligned for the approach, the eCFI announced, "Santa Rosa Tower: Mayday, Mayday. Experimental Alpha Tango 11 miles South at 6500 feet. Pilot incapacitated. Landing Runway 32. Squawking 7700 with flashing landing lights. Alert traffic. Repeat. Pilot is incapacitated. This is an automated message."

The STS tower controller, who had already identified the 7700 transponder code on her radar scope, responded, "Alpha Tango, how do you hear?" Receiving no reply after two transmissions, the controller announced that a pilotless aircraft was approaching from the southeast for a straight-in landing on Runway 32 and that all runways and traffic patterns must be cleared immediately. Fortunately, traffic was light and all of the pilots quickly complied.

Meanwhile, the eCFI adjusted the throttle to initiate a 500-fpm descent while trimming Alpha Tango to 90 knots. Pre-programmed with Alpha Tango's known glide ratio of 16:1 and stall speed of 45 knots, the eCFI had flown to a point 1500 feet AGL and 4 miles from the approach end of Runway 32, where it made a gentle turn to the final approach heading of 320° and tracked inbound using the GPS signals. Since the eCFI had no actuators for Alpha Tango's disc brakes, John had programmed it to check wind and to land into the wind. As Alpha Tango began its final approach, the eCFI noted the requisite headwind, with its GPS groundspeed reading 15 knots less than the true airspeed.

The eCFI extended the flaps and used the aircraft's automated gear-extension system to prevent a gear-up landing. It now re-trimmed to maintain a final approach speed roughly 1.3 times the aircraft's stall speed. A slight crosswind required a crab of 3° to the right of the runway heading to maintain a ground track exactly aligned with the runway centerline.

The eCFI's coupled approach was

near perfect. At a GPS height of 35 feet AGL, cross-checked with local altimeter, Alpha Tango crossed the end of Runway 32. At this point, the eCFI began re-trimming to further reduce airspeed to just 5 knots above stall speed. This resulted in a gradual flare as the aircraft settled into ground effect, just 4 feet off the pavement, wings level, nose high and 3° to the right. As Alpha Tango's left maingear squeaked onto the pavement, its tricycle gear righted the yaw angle as the other two tires touched down. As the landing gear's "squat switches" made contact, the eCFI closed the throttle and turned off the magnetos as programmed in the "pilot-incapacitated" situation. The propeller stopped as the aircraft slowly rolled to a halt in the gravel on the right side of the runway, not far from the fire truck that had been alerted by the tower operator.

## Happy Ending

Firefighters unbuckled a sleepy little Nate and drove him to the fire station, while paramedics attended to John. The ground crew found Alpha Tango completely intact and turned off its master switch as well as its independent power supply to the eCFI. As they rope-towed the plane clear of the runway and toward the transient parking ramp, normal traffic pattern operations resumed at STS.

John was admitted in serious but stable condition to the local hospital. While Nate's parents drove to Santa Rosa, the airport manager and rescue crew gave Nate a special tour of the fire station and the Pacific Coast Air Museum.

This story brings up several questions about the eCFIs in our future:

1. *Since pilot incapacitation is very rare, what other, more common types of accident might a homebuilt eCFI prevent?*

According to the 2004 Nall Report from AOPA's Air Safety Foundation, pilots cause 78% of fatal accidents and mechanical or maintenance problems cause another 10%. The main causes of fatalities in homebuilt aircraft are as follows:

- 39% Maneuvering, with almost equal numbers due to loss of control and hitting terrain, wires or trees.
- 11% Weather, about 90% of these involved flying VFR into instrument meteorological conditions (IMC).
- 11% Fuel mismanagement.
- 8% Descent/approach.

Together, these account for nearly 70% of fatal homebuilt accidents. The extremely low accident rate of flights on which an active CFI is aboard would argue that the majority of such accidents could be prevented. It is not possible to have a real human CFI on every flight. However, eCFIs, even basic homebuilt ones, might someday substantially reduce these types of fatal accidents.

2. *What kinds of things could an eCFI sense and do?*

Homebuilt eCFIs could sense roll and pitch angles, angle of attack, G forces, airspeeds, altitude above ground level, and flap and landing gear position. They could monitor fuel quantity, water-

NASA's Naturalistic Flight Deck (NFD) was developed as part of its Personal Air Vehicle Sector program. As the trendsetter for eCFIs, it has a very sophisticated "haptic control" system with fly-by-wire control plus elaborate sensors and feedback for the pilot. A guiding principle for the NFD is that the pilot must remain engaged and participating rather than merely relying on fully automatic flight.

in-fuel, cabin carbon monoxide and smoke, as well as the pilot's pulse, blood oxygen level and even alcohol breathalyzer. Further, eCFIs could sense engine parameters such as CHT, induction icing, oil temperature/pressure, oil contamination and fuel pressure. Higher tech devices could use uplinked data to monitor turbulence, weather, traffic and changes in airspace restrictions.

Prompts of graded urgencies issued by an eCFI could alert the pilot to any sensed parameters that were changing or out of normal range. This could include rising engine temperatures, induction icing or falling oil pressure. More sophisticated eCFIs could help avert loss of control, guide and control approaches, and forewarn of Controlled Flight Into Terrain (CFIT) using the GPS Terrain Awareness Warning System (TAWS). These are all capabilities that an eCFI could implement with today's technology.

By comprehensive, simultaneous monitoring of multiple channels of information, the eCFI will provide a better scan than the best of pilots, but the brain of the eCFI must be programmed to correctly interpret the facts it detects and respond appropriately. It must present its information to the pilot in a way that is easy to comprehend. Each component of the eCFI system must be super reliable and redundant whenever possible. A failure of just one component must not result in failure of the entire system. All eCFI interventions must be fail-safe and have internal self-checks that continuously validate their data's integrity.

3. *What about the time it takes for the eCFI to figure out that it must act?*

Every fraction of a second counts as the eCFI analyzes the sensor data, decides what to do and then does it. The shorter the delay before intervention, the more types of accidents can be prevented. The ideal system would assign a priority/time-pressure to each hazard and be able to react in nanoseconds if necessary.

Basic homebuilt eCFIs can be developed to provide valuable first-alert capabilities that save lives. These eCFIs would present lower time-pressure alerts such as to steer clear of restricted airspace, staying on course/altitude, checking fuel supply or engine temperatures. Basic eCFIs can evolve toward faster systems such as the seamless, near-instantaneous hazard awareness and aversive

actions of NASA's fly-by-wire, force-feedback side-stick in its Naturalistic Flight Deck (NFD).

Andy Hahn's excellent report *Next Generation NASA GA Advanced Concept* (available at http://cafefoundation.org/v2/pav_pavchallenge_studies.php) compares the operation of Ken Goodrich's NASA NFD to riding a horse; thus, it is called "H-mode":

"The H-mode is a full authority flight control system that, theoretically, is capable of fully autonomous flight. If the pilot stays fully engaged and makes no mistakes, then he will never know that the H-mode is there...Pilot and machine communicate intent through tactile feel and each does its part. The pilot does not directly manipulate control surfaces, just as the [horse] rider does not place each individual hoof... If the pilot tries to perform a dangerous maneuver, the H-mode will attempt to take corrective action, just as the horse will balk when the rider instructs it to do something that might harm it...the pilot is always in command and can always override the H-mode simply by applying more forces."

4. *How will eCFIs interface with avionics?*

Advanced eCFI systems must be able to operate avionics in order to make autopilot landings. For this important safety advance to happen, avionics manufacturers and software service companies need to participate by supplying reference guides that detail data streams and standardized interfaces (such as USB, NMEA, ARINC, etc.) to knowledgeable eCFI developers. Such developers could then use that information to extend the capabilities of their eCFIs. Access to data streams from uplinked weather and traffic services could allow eCFIs to assist pilots in steering clear of thunderstorms, severe weather and traffic.

5. *What if the eCFI-equipped aircraft attempted to auto-land at an extremely busy airport like LAX or O'Hare or at a smaller non-tower field using Unicom?*

The early versions of eCFIs will likely not have auto-landing capability and instead be much simpler monitoring and alert systems. Once a life-saving auto-landing capability evolves, it should not imperil the lives of others. Its rare occurrence as an inconvenience or annoyance would, one hopes, be tolerated and accommodated by those in the existing ATC system, as in the case of Alpha Tango. With enough grass-roots adoption and quality development, disruptive technologies such as the eCFI can earn a place in ATC and the Next Generation Air Transportation System (NGATS).


When John and little Nate took off in Alpha Tango, they never expected its homebuilt eCFI to save the day.

6. *Should an eCFI deploy a ballistic parachute?*

Yes. Cases involving an unrecoverable spin or a structural failure from a mid-air collision, if high enough AGL, are examples where assisted or even automatic deployment of a vehicle parachute by the eCFI could save lives. In the Alpha Tango scenario, the eCFI landed an intact aircraft at a place where skilled paramedic and fire-fighting resources were alerted and on hand. Alpha Tango never lost control and no person or structure on the ground was injured.

7. *Can an eCFI serve as a flight instructor to the pilot?*

Unofficially, yes. Although no replacement for real CFIs, an eCFI could be an important tool in improving the quality of time spent with a CFI and in helping pilots maintain proficiency. NASA estimates that systems like the eCFI could offer a substantial time reduction in pilot training, thus reducing the cost of obtaining a pilot certificate. In addition to presenting a pilot with alerts, warnings and advice, eCFIs can record, grade and issue comments on a pilot's performance on each flight. They can score pilots on the tasks and scenario drills normally taught by flight instructors and thus enhance the goals of the recently enacted FAA/Industry Training Standards (FITS) program (faa.gov/avr/afs/fits). Ideally, the future eCFI, like a human CFI, will be capable of salvaging a pilot's deteriorating landing or preventing loss of control through increasingly strong cues and interventions, including ultimately taking control of the aircraft. Any eCFI that a pilot purposely disabled should be designed to turn itself back on after 30 seconds or so.

8. *Are there any other benefits from the eCFI?*

Yes. The eCFI could facilitate standardization of flight controls such as the side-stick controller and single power lever. It could also help personal aircraft develop consistent, user-friendly

handling qualities similar to those found in rental cars. Such user-friendliness will be a key factor in growing general aviation's user base in the second century of flight. This is why user-friendliness will be a major factor in determining the winner of the $25,000 NASA Personal Air Vehicle Handling Qualities Prize in 2007 ( to learn more, visit www.cafefoundation.org).

In today's airspace, the scarcest commodity in the cockpit is the pilot's attention. The eCFI can tremendously extend that attention. However, as avionics and sensors have advanced to display more and more information, their complexity demands that pilots take lengthy classes to learn how to master them. The head-down-display fixation that pilots tend to get from the cluttered screens of today's moving maps can be hazardous. The head-up-display (HUD) should become the new standard. Advanced displays with traffic/weather information and synthetic vision will need simplifying and standardizing to become more interpretable at a glance. This will demand attention to the neurology of how humans best perceive and act. The goal should be to develop eCFIs that reduce pilot workload while maximizing situational awareness.

Builders of homebuilt aircraft can be important contributors to such development. The CAFE Foundation plans to openly share and promote eCFI technologies through its web site. A generic side-stick control, whose underpinnings, sensors and wiring harness could be fitted to many different LSAs, PAVs and homebuilts, is a worthwhile and attainable design challenge for EAAers. With care taken to assure the pilot's ability to maintain command with manual override, such devices could be rigged so as to safely flight-test them on VFR days in low-traffic areas.

Now is the time for EAA's "garage bands" to start building eCFIs. If we are to grow general aviation's user base to a sustainable size, we will need to adopt and implement technologies like the eCFI. Next month, in Part 2, we'll look at some hardware solutions. ✚

Build Your Skills

The humble but noble tongue depressor. Shape it into a custom tool and let the epoxy coat it for extreme use.

# COMPOSITES

## In Part 2, we'll discuss what you'll need in the way of tools, supplies and a workbench.

BY BOB FRITZ

Not likely to be mistaken for paint rollers, these are used in much the same way to smooth out the fiberglass.

Do you find operating a ballpoint pen a difficult task? Is a layer cake with canned frosting a tough assembly? No? Then working with composites is within your grasp. Last month we reviewed the basic materials and found that one end of the fiber spectrum is made up of boat hulls built of chopped E-glass held together with polyester resin; the other is multi-million-dollar aircraft made of single-strand Kevlar and carbon fiber laid down by multi-million-dollar machines. We homebuilders are in the middle of those extremes, doing layups of cloth made of S-glass or E-glass, and using either epoxy resin (ER) when needed for strength and vinylester resin (VR) the rest of the time—or when the kit manufacturers choose to use each of those materials.

Typically, the choice is dictated easily by simply choosing the lowest cost material that meets the mission profile. An excellent example is Van's RV aircraft, which use vinylester resin on the wingtips and epoxy resin on the cowling. You can spot the difference easily enough; the VR parts are white, and the ER parts are a transparent greenish color. But with that choice comes a new set of decisions: What tools are needed?

Ever get really ticked off when you see your screwdrivers being used to dig weeds? "^@#$%, use the right tool for that!" Uh, huh. Use the right tool. So it is with composites, and though a lot of these items look like refugees from a Chinese kitchen,

No, it's not a pizza cutter. It's a rotary cutter (aka circular razor blade).

The scissors are pricey, so labeling them will make them less likely to walk away.

The table and cloth rack are essential. The hat is optional.

they are no more so than a screwdriver is a weed digger. It works, but the right tool works better.

So what's different about working with fiber? Well, you have two basic materials to work with: cloth and resin. Unlike working with aluminum, you also have a timing issue. You can't stop in mid operation and take it up tomorrow without expecting some back up and restart. There are also health issues that are unknown in metal work. And while the rivet bangers like a big workbench as much as anyone, for the glass guys it's not an option.

## Getting Started

Let's begin with how to handle the materials. The first thing you'll need is a large, flat, smooth surface devoted to cutting cloth. If you try working this stuff on your regular workbench you're asking for trouble for a couple of reasons: One, the material needs to be kept clean. That means no oils, water or general dirt should come in contact with the glass. Oil and dirt seem obvious as contaminants, but water? Yes, water. There's a coating on the fibers that assists the epoxy in wetting the fiber; water removes that coating.

You've also noticed the black diagonal lines on the table. You might have heard your mother refer to a dress as having been cut on the bias. The term simply means cutting at an angle instead of straight across the material. It's a way of keeping the cloth from de-weaving. The marks on the table are at 45° to the cloth and serve as a guide.

The second reason for a large, flat workspace is that cut material tends to de-weave itself, so the less handling the better. More on this later.

As for the surface of the table, you should cover it with a smooth, plastic sheet. Don't use wood; the splinters will embed into the cloth. And forget metal; it will dull the cutters. Although Melamine looks nice, it too will cut and release contaminants. Plastic...that's the ticket.

The trick to cutting the fabric is to understand that it has a coating that encourages the movement of the fibers over themselves; the stuff is slippery. It can be a curse when cutting, but it's what makes it conform to complex shapes.

## The Blade

Now that you have a table surface, you'll want a cutting wheel. No, this is not a refugee from a pizza joint; it's a circular razor blade. These come in several sizes, but the 45mm diameter is the best all-around tool for cutting long, straight lines and curved corners. Keep it on the worktable and don't use it for any material that's been soaked with resin. The solvents are hard on the handle, and though there are aluminum-handle versions available, any contaminants remaining on the blade will ruin it for further use.

There are all-aluminum models that can be stored in a can of solvent, but that requires keeping a liquid in the cutting area or doing a careful job of clean-

Once you're done cutting, you have to be careful moving the strips so that they don't de-weave.

*Photos: Bob Fritz and Courtesy the Manufacturers*

ing and drying prior to cutting on the table. Better to simply keep your cutting wheel clean and dry, advises Dave Saylor of Aircrafters.

Now that you see the tool, let's go back to the table and explain why we want this tool and that table. Once you've marked your cut with a Sharpie, you need to cut it out. But because the glass cloth is a loose weave, lifting it off the table to get at it with scissors distorts the fabric. Remember that term "drapeability" from the first installment of this series? It's helpful when you want the fabric to conform to a compound curve, but in this operation it's a hindrance. The solution is to cut the fabric without lifting it off the table. Using a cutting wheel against a flat table does just that, and having a backing of firm plastic ensures that the wheel cuts through the glass without dulling the blade.

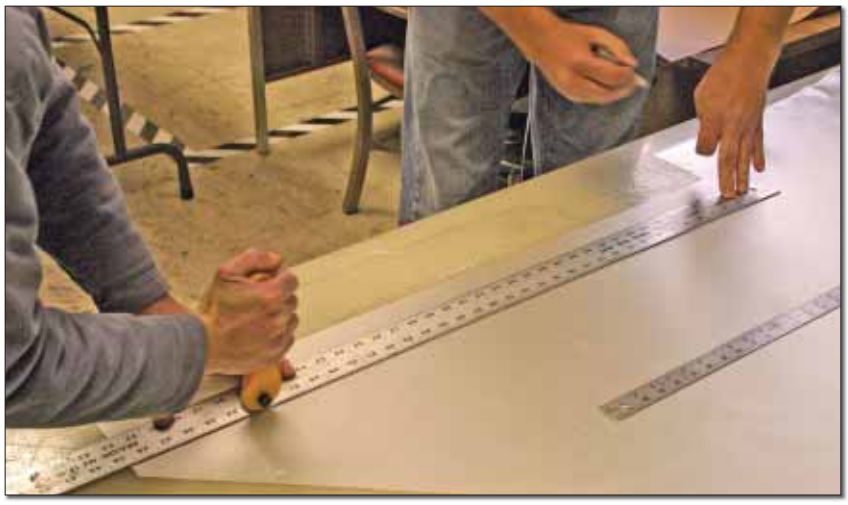
Transporting the pieces to the worksite is not a grab-n-go operation; you'll get to your destination with loose threads all over the shop as the fabric deweaves itself. Instead, have a large board on which you can place the cut pieces and carry them to the worksite. A large sheet of paper will do if you have a helper to grab the corners. This is especially critical when doing a multi-piece layup such as the one around the leading edge of the windshield on the RV-10. (Hint: We're demonstrating that operation in the next issue.)

Scissors seem like an obvious requirement. But don't plan on appropriating them from the sewing kit; there's a difference in the hardness and the edge profile on glass scissors that makes them work better. Good ones will cost about $30, so that should tell you something. You'll find these are useful to cut the wetted glass that overlaps into areas it shouldn't.

If you're going to add a bit of Kevlar to the project, then plan on buying special scissors for that as well. They look just like all the other scissors, so painting the handgrips a nice bright color would be a good way of differentiating your $60 purchase. The blades have tiny diamonds adhered to the edges. One use of these scissors on some material that's been wetted with resin and the neighbors will learn a whole new set of words not to be repeated in polite company when you discover that resin has coated the sharp corners of the diamonds and now they won't cut hard butter.

## Dabbling in Fluids

Now that you have the material to the worksite, you're ready to start playing with the liquids. That means latex gloves and lots of them. Ultra-cheap ones tear easily, and you'll find that they are more expensive because of it. But you don't need surgery-qualified ones either. Dave



Using the rotary cutter is surprisingly easy. Just don't trim your fingernails with it.

You want air over the wing, not in it.

Saylor recommends powdered gloves. "They're easier to put on, and the powder is on the inside so it's not a problem for the material," he says.

Rollers are used to squeeze out the bubbles and force the epoxy into the yarns on large, relatively flat surfaces. At first glance it would seem tempting to think these are great for use in curved areas, but in working on the RV-10 windshield I found it easy to push too hard and displace the layer of cloth. The flexibility of the paint brush reduced that tendency. However, you will need several sizes for large and small areas, and you don't get these puppies at the local hardware store; they are not overpriced paint rollers. For instance, there are various lengths and diameters, but also curved ones, finned ones, and some that look like a pizza wheel gone insane. We'll describe the uses of each as we progress with this series.

At first glance, peel ply may seem to be a material more than a tool. However, its function is the same as the paint brush or roller. It's a 2- to 3-inch-wide strip of Dacron that laminates onto the layup as the last layer and is used to squeeze out excess resin. It cures along with the rest of the material, but it doesn't adhere to the resin. Saylor was adamant about its use: "More epoxy does not make a stronger component," he said. "Using peel ply correctly will let you squeeze out the excess resin and give you a lighter, smoother part." An added benefit is that when you peel it off you have a surface ready for further work without sanding. Handy stuff.

Among the essential tools is the humble 1-inch-wide paint brush. Buy the cheapest ones you can, and buy them by the box because you'll throw them away after one use. The obvious uses are slathering on the epoxy and pushing the cloth into position; the not so obvious use is that when you cut them to about 3/8-inch, they also are perfect for smoothing out the bubbles under the peel ply. That white-ish dot (see photo) by the handle of the brush is an air bubble. Resin has a hard time sticking to air, so white is not right.

Some of my favorite tools are not only the least costly, but they also get better with use. They're ordinary tongue depressors filed and shaped to conform to most any job. They get coated with the epoxy and when it dries, they're harder and smoother than the original. Create a few of these in your shop and keep some in your shop coat. But wait until the epoxy has hardened or you're in for a surprise when you grab one.

Here's a disaster scenario: The epoxy is setting, and you see the need for a bit more cloth. There's only one problem. You suddenly find that the tool you want grew legs and walked off. In 30 minutes that epoxy will be jelling, and you are about to panic.

## Your Workshop

The answer to this problem is not two or three of everything; that's an unnecessary cost and means you have to keep track of more tools. You wouldn't make dinner on your workbench; you'd go to the workshop specifically suited to the task, the kitchen. Therefore, your composites workshop needs one thing: a workbench sized so that the parts and all the right tools you need are close at hand. There's the key: close at hand. This will solve a lot of the problems. Build yourself a mobile work station devoted to composite work. It only needs to be about 2x3 feet, on wheels, and with enough room to carry all the chemicals, tools, materials, gloves, measuring and clean-up supplies in one place.

Next month we'll start to discuss the specifics of how to use all of this in the fabrication of an actual aircraft. We'll be following various stages of construction of a Lancair IV-P owned by Bill George (that's him behind the cutting table), and whatever Dave Saylor of Aircrafters in Watsonville, California, happens to be working on. To learn more about Aircrafters, I'd recommend a visit to his web site: www.aircraftersllc.com. ✚

A short brush is useful for getting the air bubbles out of the laminate.

Jed at SteinAir is either setting up an audio panel or searching for game highlights.

PART 3

**Backup instruments will be your very best friend should that EFIS go dim.**

BY STEIN BRUCH

# ALL ABOUT AVIONICS

Now that you've finally decided which EFIS you're going to buy, it's time to consider backups. You'd think that with all the modern assortments of glass panel EFISes and graphical widgets, we'd pretty much have our panel complete, right?

Well, that's almost true. If you're planning on using your new plane only as a day/VFR fun flyin' weekend hamburger/pancake getter, then the requirements for instruments and avionics are simple. You can get by with a single EFIS, add a GPS, com radio, transponder/encoder, engine instruments—and go fly!

A traditional, mechanical altimeter backs up this Chelton EFIS. The autopilot will keep the wings level should the EFIS blink out, and the altimeter will keep you out of the rocks.

## The IMC Plan

But if you plan on flying cross country or IFR, it's prudent to back up those snazzy EFIS devices with secondary instrumentation that will keep you alive should the primary system or systems go off-line.

What do we mean by backup instruments? Simply put, they are secondary redundant indicators or instruments that will give you basic flight information should your primary system fail or, worse, become unreliable. (And here we don't mean fail to work, but rather fail to give accurate readings, something that's been known to happen and is very difficult for a pilot to troubleshoot in the heat of battle.)

Historically, backups weren't a big concern because with the standard six-pack, they were by nature independent and to some extent redundant. All but the power system for the main gyros, of course, which was traditionally a vacuum pump mounted on the engine. History records that the dry vacuum pump can be either fairly reliable or not at all so. With two of the primary gyro instruments powered by it, the likelihood of two of the three keep-my-wings-on instruments failing at the same time was distressingly high. The bad thing about a vacuum system failure is that you normally have little warning, and unless you are specifically watching your suction gauge, you might not notice the vacuum system has failed. This means a slow decay of attitude or directional indication, which has resulted in the deaths of many fellow aviators.

Normally backups are a completely different system from the primary and should be powered either via a backup battery or a different source than your primary flight system. That's the goal of a good backup strategy: Separate the power sources and technology types so that the failure of one instrument won't

This Blue Mountain EFIS is backed up with a combination of traditional pitot/static instruments and a TruTrak ADI. It's important that the backup instruments remain close to the primary scan; way off in right field isn't very useful.

affect another, the failure of one power source won't affect all the instruments, and so that an outside factor—lightning strike or P-static—won't affect all of your instruments similarly.

In this installment, I'll relate the experience I've had at SteinAir with various systems and components. But be warned these are somewhat subjective and murky waters. While I think our experience is valid, and the feedback from my customers accurate and worthwhile, this cannot be an end-all verdict on any system or component. There are too many variables out in the real world for this to be true, so take my suggestions for what they are: educated by experience but not necessarily the last word on the subject.

## A Surprising (Maybe) Suggestion

In my view, the best backup is an autopilot, followed closely by having another attitude indicator or attitude direction indicator (ADI). Modern autopilots incorporate some sort of flight instrumentation, but more importantly they can fly the airplane in conditions where the average pilot may get disoriented. Many pilots, even experienced aviators, can and will find themselves in situations they didn't intend to be in. In the case of the famous "declining weather" or inadvertent flight into IMC, switching on even the simplest autopilot will give you a better chance of surviving.

All of today's autopilots will fly the airplane with a good deal of precision, and all of them will allow you to get out of trouble a lot more easily than you could before. (I won't get into detail on the available systems because next month we'll be doing an exhaustive

Backstopping a pair of Grand Rapids displays, the Blue Mountain G4 Lite is positioned so the copilot has something to play with on long cross-countries. It may not be positioned ideally for the pilot as a primary reference, but it's sure better than nothing.

Even though this F-1 Rocket panel is compact, there's enough room for a pair of Cheltons and a Dynon EFIS-D10A backup. This is a smart form of electronic backup, using two distinctly different designs and vendors.

This RV-7A panel employs a TruTrak ADI to ride shotgun for the Dynon EFIS-D100, but it also features traditional backups for airspeed and altitude, a two-axis autopilot and a Garmin GPS centrally mounted.

*Photos: Stein Bruch*

review of the available autopilots.) With our RV-6, we flew for several years with no autopilot because we figured "we like to fly," and "RVs are easy airplanes to fly," so we don't need an autopilot. Three years ago we installed an autopilot, and frankly it's such an amazing bit of technology that from now on any airplane we build will first and foremost have an autopilot before I spend money on any other goodies! The autopilot will almost always fly the airplane with more precision than a human (they don't suffer from vertigo or spatial disorientation), and in IMC the autopilot is a valuable tool for not only flying the airplane, but relieving the pilot's workload to focus on additional tasks, communication, chart reading or dealing with an engine problem.

## Gyro-Based Backups for EFIS

A backup or secondary gyro (attitude indicator or ADI) is a wise addition to any panel. Our choice is electrical gyros, mainly because they have proven themselves to be much more reliable than their vacuum-powered brethren, plus vac systems add unneeded complexity and weight and are prone to failure without much warning.

**Falcon Gauge.** Falcon offers a variety of instruments including airspeed, altimeter, engine, clock, etc. It offers both an electric and vacuum version of its attitude indicator, but it recently has been extremely hard to procure, and quality/reliability of these units hasn't really stood up to the competition—particularly in terms of consistency. Many people are having good luck, but others have been unable to achieve acceptable results. Some of the Falcon instruments are great, and for the cost of the unit they seem affordable. But until the company improves its reliability and delivery schedule, we're going to steer clear.

**Price:** $1300.

**Mid Continent Instruments**. Mid Continent is the only manufacturer to offer a traditional attitude indicator/gyro with an internal battery. The Lifesaver gyro's internal battery provides up to 1 hour of usage with no external power required in the event of an emergency. This $3^1/_8$-inch gyro is proving to be very popular. Input voltage can be 10-32, meaning that it can be installed in either 14V or 28V aircraft with ease. Mid Continent also manufactures a small $2^1/_4$-inch standby electric attitude indicator, but it's fairly pricey at about $3500.

**Price**: $4000 ($3^1/_8$-inch electric Lifesaver gyro with internal battery).

**RC Allen**. Now manufactured by Kelly Manufacturing, RC Allen has been one of the industry leaders in gyro products for many generations. It offers vacuum and electric instruments in a variety of configurations (lighting, caging and voltages). There are literally thousands of these instruments flying, and overhaul services are still available. We've found them to be reliable, but

Falcon's electric DG could be part of a backup suite or a primary heading indicator for an all-electric, non-EFIS setup.


Falcon turn coordinator.


Falcon vacuum gyro.


Falcon $2^1/_4$-inch ASI.


Falcon electric gyro—note the lighting wires along the top, forward edge.


The Mid Continent Lifesaver gyro can be fitted with an internal backup battery.

as with any traditional gyro that uses a spinning mass of metal, they tend to be on the heavy side. We've not installed many of these gyros, but we do know many people flying behind them with good results.

**Price**: $2000 (electric).

**Sigma-Tek**. Formed after the spinoff of EDO-Aire from EDO in the early 1980s along with the assets of ARC (Aircraft Radio Corporation), Sigma-Tek now is a popular manufacturer of vacuum-powered gyros. These gyros have a proven history of reliable service with many units installed. We fly behind a set of Sigma-Tek vacuum gyros in our RV-6 and have had good luck with them over the past four years.

**Price**: $800 (vacuum only).

**Sporty's**. Produced by Castelberry Instruments for Sporty's, this TSO'd attitude indicator is indeed a quality $3^1/_8$-inch instrument available in 14- or


RC Allen electric AI.

28-volt with built-in inclinometer and quick erect knob. It was designed to be a backup to traditional vacuum-powered gyros in production airplanes, replacing the turn coordinator. This is a nice electric gyro, which is a good option for your Experimental or certified plane. We've installed several of them and are impressed with their quality.

**Price**: $2000.

**TruTrak Flight Systems**. The ADI from TruTrak is hard to classify. It's technically not a gyro, but then again it's unique and really doesn't fit many current categories of instruments. Created by Jim Younkin (holder of many aviation patents), this instrument at first glance may appear to be an attitude indicator, but it's more. It differs in that it basically uses "gyro stabilized vertical speed" for its pitch presentation. The display includes GPS-derived heading information (either from your existing GPS or from an internal, optional GPS module), a slip-skid ball and red-lighted arrows under the horizon that flash and tell the pilot which way to

This Harmon Rocket panel uses a TruTrak Pictorial Pilot turn-and-bank/autopilot as the main attitude backup instrument.

| Traditional Backup Instruments | | | | |
|---|---|---|---|---|
| Mfr. | ASI | VSI | ALT | T/C |
| Falcon Gauge | 3.125/2.25 in. | 3.125/2.25 in. | 3.125/2.25 in. single pointer only | 14V or 28V electric, 3.125 in. only |
| Mid Continent | 2.25 in. | | 2.25 in. three pointer | 3.125 in. |
| UMA | 3.125/ 2.25 in. | 3.125/2.25 in. | 3.125/2.25 in., both single pointer only | N/A |
| TSO'd | | | | |
| United Instruments | 3.125 in. | 3.125 in. | 3.125 in. | 3.125 in. |

| Gyro Backup Instruments | | | | | | |
|---|---|---|---|---|---|---|
| Mfr. | Model / Series | Type | Volts | Panel Tilt | Lighting | TSO'd |
| Falcon Gauge | GH02V-3 | Vacuum | | 0 or 8° | | |
| | GH02E-3 | Electric | 14V or 28V | 0 or 8° | Optional | |
| Mid Continent | 4300 Lifesaver | Electric | 10-32V | 0-20° | Standard | Y |
| | 4200 | Electric | 10-32V | 0-20° | Standard | Y |
| RC Allen | RCA 22 | Vacuum | | 0 or 8° | Optional | Y |
| | RCA 26 | Electric | 14V or 28V | 0 or 8° | Optional | Y |
| Sigma-Tek | ST 5000 | Vacuum | | 0 or 8° | Optional | Y |
| Sporty's | 2060A | Electric | 14V or 28V | 0° | Standard | Y |
| TruTrak (ADI) | ADI | Electric | 12-28V | 0° | Standard | |
| EFIS (for a more comprehensive guide to EFISes, see our May 2007 issue) | | | | | | |
| Blue Mountain | Lite G4 | | | | | |
| Dynon | D-10A | | | | | |
| Stratomaster | Horizon | | | | | |

Even the comparatively small RV-4 panel can have backups. Here, a single-screen Grand Rapids EFIS has independent airspeed and altitude instruments plus a TruTrak Pictorial Pilot turn-and-bank instrument that houses an autopilot controller. Note the "natural" placement of the backup ASI and ALT, right next to the digital representations on the GRT.

move the stick in the event of an unusual attitude. It takes a few minutes to get used to the reaction of this instrument, but you'll find that flying behind it for a while, and keeping the little airplane centered offers you more precision than a standard attitude indicator—you just have to fly it differently. Currently the ADI is the most popular standalone backup instrument we sell. Now offered in the $3^1/_8$-inch size, TruTrak hopes to begin delivery of the $2^1/_4$-inch size within the next several months.

**Price**: $1350 ($3^1/_8$-inch size with backup battery and internal GPS).

## Another EFIS to the Rescue

Now that I've just finished expounding the virtues of gyros, I'll perhaps sound a bit hypocritical when I say that I think many small self-contained EFISes are a better value as a backup instrument. For the same price or less than many available electric gyros, you will have an instrument that displays attitude indication, airspeed, altitude, heading and a variety of other information. There are now many affordable EFISes on the market, but we're going to limit this discussion to those that will fit into a standard panel cutout (either $2^1/_4$ or $3^1/_8$ inch).

**Blue Mountain Avionics**. The EFIS Lite G4 from BMA is a wonderful

| | T&B | Price | Notes |
|---|---|---|---|
| | 2.25-in. only, 10-30VDC | $125 - $275 | Offer true airspeed, dual range airspeed and lighted instruments. All instruments Non-TSO'd. |
| | 2.25/3.125 in. | $700 - $3750 | High quality certified . |
| | Inclinometer only. | $130 - $320 | Custom range markings available; used by many kit mfrs. |
| | | | |
| | 3.125 in. | $420-$585 | All are TSO'd. True airspeed available. |

| | Inclinometer | Backup Battery | DG/Heading | Size (in.) | Depth (in.) | Weight | Price |
|---|---|---|---|---|---|---|---|
| | | | | 3.125 | 6.5 | 2.5 lb. | $385 |
| | | | | 3.125 | 6.5 | 2.5 lb. | $1100 - $1200 |
| | Optional | Optional | | 3.125 | 6.6 - 8.6 | 2.4-3.7 lb. | $3900 - $4700 |
| | | | | 2.25 | 6 | 1.5 lb. | $3200 - $3550 |
| | | | | 3.125 | 6 | 4.0 lb. | $600 - $900 |
| | Optional | | | 3.125 | 7 | 4.0 lb. | $1900 - $2100 |
| | Optional | | | 3.125 | 7.125 | 4.0 lb. | $700 - $1640 |
| | Standard | | | 3.125 | 6 | 3.8 lb. | $1950 |
| | Standard (in 3.125-in.) | Optional | GPS Driven (internal or external) ground track | 3.125/2.25 | 4.6 | 12 oz. | $1100 - $1300 |
| | | | | | | | |
| | | Optional | | 3.125 | | | $3495 |
| | | Optional | | 3.125 | | | $2350 (w/backup battery) |
| | | | | 3.125/2.25 | | | $1095 (2.25-inch gyro w/compass module) |

little EFIS that mounts in a standard $3^1/_8$-inch instrument hole. It comes with all of the functionality mentioned above, plus a WAAS GPS and terrain mapping. It also has the capability to communicate with the SL30 nav/com to display VOR/ILS information and act as an HSI/CDI. The EFIS Lite is available with a backup battery as an option. BMA is working hard to correct its history of delivery problems and reliability issues. The current small EFISes that we've worked with from BMA appear to be nice boxes with nice functionality.

**Price**: $3495.

**Dynon Avionics**. The D-10A is another great little EFIS that mounts in a standard $3^1/_8$-inch instrument hole. While not quite as capable in functionality as the Blue Mountain, Dynon has literally thousands of these units in the field with a high reputation for quality and delivery, and it is by far the most popular of the bunch. With its internal battery and optional communication with most GPSes and the SL30 radio, it can also act as an HSI/CDI.

**Price**: $2350 (with backup battery).

**Stratomaster.** The Horizon attitude indicator is relatively new to the market, and these "smart singles" (available in either $2^1/_4$ or $3^1/_8$ inch) are lightweight stand-alone, solid-state units. The monochrome screen displays the horizon along with a slip-skid indication, and the optional compass module lets you display heading as well. We don't have a lot of experience with these units, but the company seems solid, and the products appear to be a good value. Stratomaster also offers a complete line of stand-alone digital singles such as altimeter, airspeed and VSI at reasonable prices.

**Price**: $1095 ($2^1/_4$-inch gyro with compass module).

Sigma-Tek gyros in an RV-6 panel—definitely old school but still viable.

Chelton with UMA backups.

This is a wise layout for backup instruments: Keep the secondaries in the pilot's line of sight. It's hard enough reverting to "steam gauges" at a moment's notice.

## Instruments for Traditionalists

Beyond instruments to keep the wings level—more or less—you should consider a backup airspeed and altimeter.

**Falcon Gauge**. Falcon's line of airspeed indicators, G-meters and altimeters has proven to be a pretty good buy, being both reliable and affordable (much more so than the company's gyros). They currently offer both $2^1/_4$- and $3^1/_8$-inch altimeters and airspeed indicators. We especially like having a G-meter (aka "fun meter") in our RV-6. Falcon also offers a nice combination chronometer and clock, which has turned out to be an impressive unit.

**Price**: $125-275.


Sigma-Tek vacuum AI.

**Mid Continent Instruments**. Mid Continent offers a TSO'd backup package of instruments that includes a $2^1/_4$-inch airspeed indicator and a $2^1/_4$-inch three-pointer altimeter. While higher priced than others, these certified instruments are engineered by Aerosonic exclusively for Mid Continent and are very high quality. Mid Continent currently offers the only readily available $2^1/_4$-inch sensitive altimeters with three pointers. Both the airspeed and altimeter come standard with internal "long life" LED lighting.

**Prices**: $700-$3750.

**UMA**. These are perhaps the most popular U.S.-made traditional instruments available. UMA produces high quality airspeed indicators used by a number of kit manufacturers, along with a wide range of small-scale (1-, $1^1/_4$- and $2^1/_4$-inch diameter) instruments. Moreover, UMA will do custom marking on any of its instruments for your aircraft. The company also offers a full line of engine instrumentation. Lastly, UMA produces our favorite light bezels, which mount in between the panel and the instrument itself. We frequently install these instruments in many panels and are impressed.

**Price**: $420-$485.

**United Instruments**. These are top of the line, high quality TSO'd instruments that include altimeters and airspeed indicators. The United Instruments equipment is higher priced than some others, but the company is also

one of the few manufacturers to offer fully TSO'd instrumentation backed by high historical levels of reliability and customer satisfaction. Lately, due to the delivery problems of other manufacturers, the United Instruments units are the only readily available three-pointer sensitive altimeters. The extra cost of these certified models is not necessary when acceptable alternatives exist, but with altimeters specifically, there are few options available at the moment.

**Price**: $420-$585.

There are many more manufacturers offering a greater variety of instrumentation than ever before. With the current generation of Experimental aircraft moving to more and more advanced cockpits, it's sometimes easy to just assume that you'll never have a failure. That being said, when you add up the total cost of your project, the extra money to equip it with a few stand-alone backup instruments won't impact your overall budget that much, and it may just save your bacon some day when you least expect it—and therefore most need it!

*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.*

Mike at SteinAir checks the backup altimeter.

Miniaturization has its advantages. This Chelton duo is supplemented by a row of 2¼-inch backup instruments. The airspeed, altimeter and VSI are from UMA; the ADI is from TruTrak; the CDI is from Mid Continent.

## CONTACT INFORMATION

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

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

**Falcon Gauge**
847/487-9960
www.falcongauge.com

**Mid Continent Instruments**
(KS) 316/630-0101, (CA) 818/786-0300
www.mcico.com

**RC Allen (Kelly Manufacturing)**
800/RCA-GYRO
www.kellymfg.com

**Sigma-Tek**
316/775-6373
www.sigmatek.com

**Sporty's (Castelberry Instruments)**
800/SPORTYS
www.sportys.com

**Stratomaster (MGL Avionics)**
310/534-2509
www.stratomaster.com

**TruTrak Flight Systems**
479/751-0250
www.trutrakflightsystems.com

**UMA**
Available from Aircraft Spruce & Specialty
877/477-7823
www.aircraftspruce.com
www.umainstruments.com

**United Instruments**
316/636-9203
www.unitedinstrumentsinc.com

Part 3

# The Home Machinist

## Comparing the options: the milling head.

BY BOB FRITZ

A pair of 8-year-old girls approach the workshop, ice-cream cones in hand. First girl in a Lily Tomlin/Edith Ann voice: "Whatcha buildin', Mister?"

Hank: "An airplane"

Pause...lick...pause. First girl: "Does anyone know?"

My friend, Hank, loves to tell that story. He says that she said it with great concern. He's working on his third airplane, so I guess by now the word is out.

Yep, number three. First, an RV-4, then a Lancair 235 with a Mazda rotary engine, now another RV-4 with a Lycoming O-290 built out of parts he had on the shelf. If you like to build, well...build. But for this sort of involvement he definitely needs, and has, a home machining center.

Speaking of knives, an end mill is sharp enough to cut your fingers even when not spinning. Here's an intake manifold being modified to take fuel injectors on my RV-6 project.

Last month in this series we described the lathe portion. Prior to that, we pointed out that it's the perception, rather than the reality, that inhibits popping for $3000 for a machining tool, while 10 times that is OK for a boat. This month all that remains true, so let's take a look at the mill head.

The milling head is the part of the mill-drill-lathe (three-in-one) machine I find most useful. It's the part that can cut a square hole or make a nice flat spot for attaching some other part. Think of it as a rotary knife; the milling head is your handle, and the end mill is the blade. It'll cut aluminum more easily than a jackknife cuts soft wood, and you'll find that it's really fun to watch the chips come flying off, exposing bright metal.

Now before you get your knickers in a twist thinking that the required skills are way beyond you, consider that both a surgeon and Tom Sawyer use knives, and so it is here. The surgeon has a high (you hope) skill level. But you're like Tom...you're whittling. By that, I mean that you should not be intimidated by the skill level of the professionals. Visualize a more realistic goal, say, Crocodile Dundee "Nah, *that's* a knife!"

What are we looking for in the mill head portion of our three-in-one machine? For starters, the same as on the lathe section. What's stationary should be solid; what's moveable should be easily moved; what's adjustable should be easily adjusted. Specific to the mill head, however, we get a bunch of terms that might as well be *Star Trek* techno-gibberish.

Let's check a set of specs for a typical machine and see if Geordi LaForge can explain.

### Mill Spindle Center to Column (Throw) 16 inches

Translation: How far can you work from the edge of the material? Importance? That's for you to decide, but 16 inches is average for this class of machine. What it amounts to is that you could drill a hole dead center in a 32x32-inch plate


A good machine allows movement of the entire milling head, thereby minimizing the amount of quill extension. That, in turn, keeps the end mill more stable. It also allows for taller parts. Here, the head is all the way down.

Here's one way of using the blocks to clamp a part above the bed. This allows you to cut through the part without cutting the bed itself. If you had an Erector Set as a kid, you'll love these.

of metal. That's larger than I've needed on my projects. For me, it's an 8 on the importance scale.

## Quill Stroke 3.25 inches

Translation: This is how deep a hole can be drilled, and it rates an 8 on my importance scale. The quill itself requires a bit of explanation. It's the cylinder of steel that supports the cutting tool. In the stability department, it's the weak link in the entire system because it not only has to go smoothly up and down, it has to allow the cutting tool to rotate while resisting side loading in any direction. If you can get your hands on a machine prior to purchase, look closely at this component and make sure it moves smoothly up and down and in no other direction.

## Quill to Table (Adjustable) 4-14 inches

Translation: On this machine, the whole mill head goes up 10 inches for extra working space. This gets a solid 9 on the Bobometer because it's so useful in minimizing the quill extension. It stands to reason that if the quill has to resist side loads, the shorter the extension the better; and being able to bring the head down to the work does just that.

## Mill Table Size 9x19 inches

This one's not even Klingon, so it's fairly obvious. However, don't be fooled into thinking it's too small. With a bit of ingenuity you can clamp some pretty irregular sizes and shapes onto the table. We'll show you some clamping techniques in a later issue. Again, this is a high score of 8.

## Mill Table Travel 10x23 inches

You clamp your material to the mill table, and the amount of travel dictates the size of the working area. The smaller dimension is the Y direction travel; the larger dimension is the X direction travel. While a two-ton, $20,000 Bridgeport mill has something like 18x36 inches, I rarely used the extra area for anything other than a worktable when I had one. Bigger is better, but this is adequate for the home shop.

## Mill Table Powered L-R and F-R, Yes

This refers to having motorized travel of the mill bed. It's nice, but vital only for the best in surface finish, thread cutting or computer control. I give it a 6 only because you're Crocodile Dundee here, remember? I've got powered L-R (Left-Right aka X axis) but use it only when making a cut longer than 2-3 inches. The F-R (Front-Rear aka Y axis) is neat but not vital.

## Spindle Taper R-8

This describes the outer shape of the collet that holds the end mill. There are 30+ shapes, but R-8 and 5C are the two most common, and there's not much to recommend one over the other. Just know that they are not interchangeable, with R-8 having a slight edge in commonality.

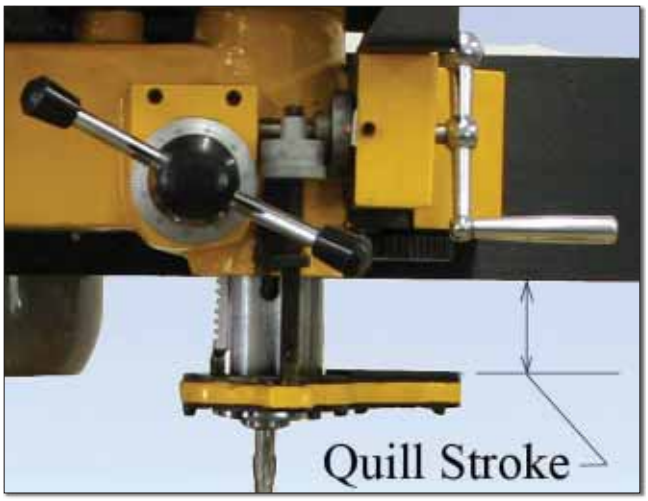
When you want to drill a hole you'll

The T-nuts and slots along with the step-blocks allow you to clamp down odd shapes...like intake manifolds.

*Photos: Bob Fritz and Courtesy the Manufacturers*

find that the drill chuck is a bit different from what you're accustomed to using on a dedicated drill press. In this case, the chuck is removable and will have the same tapered shape.

The photo shows an R-8 collet with an end mill. It's pretty obvious that you'll need a set of collets to go with a set of end mills. Don't panic, a nice set of collets can be had for less than $50; likewise a set of end mills.




A quill stroke of 3-6 inches is typical. Gross vertical movement is controlled with the 10-4 o'clock handle, fine movement by the crank, and depth control to 0.001-inch by the dial on the 10-4 handle.

## Spindle Speeds (16) 125-2400

This comes under the Bill Gates scale of importance. If enough is OK, more is better, and too much is just right. This is too much, so it's just right. Seriously, you'll only use four or five speeds, but the problem arises when the group of four or five you want doesn't include one that you have. I give this a 7 on the importance scale.

## Motor Horsepower 1.5

You don't want a wimpy half or three-quarter horsepower motor. This gets an 8.

## T-Slot Size

The T-slots are those grooves you see in the cross-slide table. They're used to bolt things down solidly so you can cut them. Most tables have two of these grooves, while some have three, and one brand has additional grooves that enter at 90° into the longest grooves. Three is better than two, and side grooves are better still for making a setup easy, so this gets an 8.

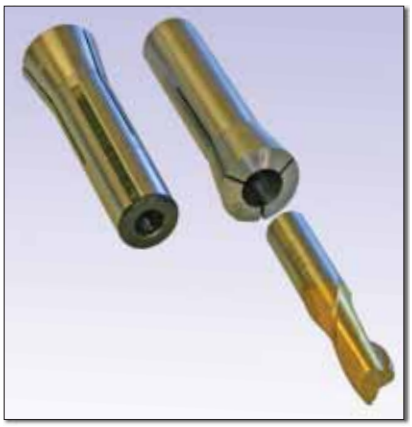
Here the milling head is all the way up. You can see the crank sticking out the top over at the left end. Make sure this adjustment is easily accomplished on whatever machine you select.


The major parts of the typical combination machine will vary in color and shape among models, but the basic parts are the same.

As for the T-nuts that go into the groove, you'll buy a set of them specifically for your machine (they're usually included on the better machines), so don't worry about it. Score: 3 on the Bobometer.

Although the T-nuts are not a point in evaluating the mill itself, a bit of explanation of their use goes a long way in understanding the entire machine. The table, as I said, has slots in it and the T-nuts fit in the slots. Here's where

An entire set of nuts and blocks is essential. If it's not part of the machine, then buy it. Next month, we'll talk about accessories and where to get them.



This is a typical R-8 collet. Each is sized to match a different size end mill. As you can see, the top end is threaded to pull the collet tight, while the keyway stops rotation as you do so.

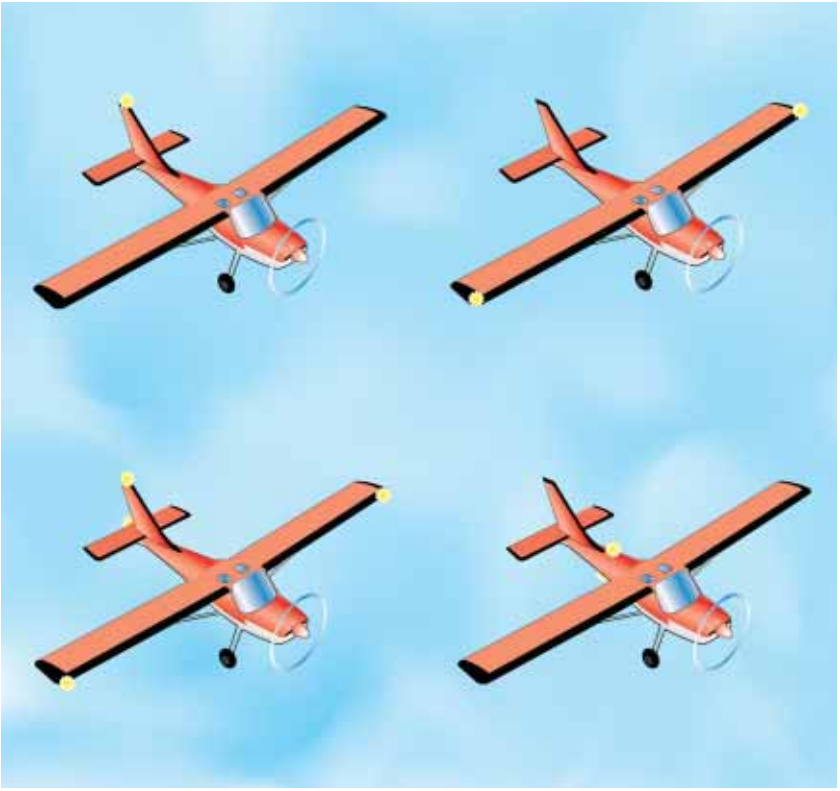
it gets to be fun. You select the clamping pieces needed for your particular setup, align the material so that the travel of the table matches the finished cut, select the cutting tool and voila. You're ready to start cutting. Just remember to clamp the material at a minimum of two places and as close to the cut as possible.

As you can see, the sawtooth blocks allow you to adjust the height easily. Of course, if you don't need to cut entirely through the material, you can build a shorter setup that clamps directly to the table. And that segues into the entire clamping setup. This is like that Erector Set you had as a kid: lots of fiddly bits that help you build something substantial.

This should help you understand the basic parts and specifications of the milling section. Next month we'll expand on the accessories and discuss some of the things that come in the box with the mill. We'll also examine a few of my favorite items and why they are indispensable in my shop.

Now go lay out the area where you're going to put this new machine!

*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.* ±



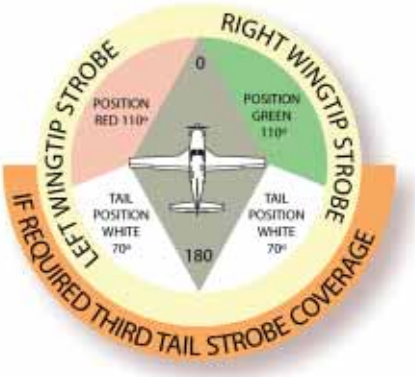
One anti-collision strobe on the vertical fin (upper left) will usually meet the FAA's minimum requirement. However, configuration for other strobes varies with the design. Wingtip strobes that protrude beyond the wingtip, whose light converges 1200 feet fore and aft of the aircraft on its centerline are acceptable. Enclosed wingtip strobes require a third light on the tail or vertical stabilizer (lower left). Two fuselage-mounted strobes are necessary to achieve the required vertical anti-collision coverage (lower right).

# Light It Up

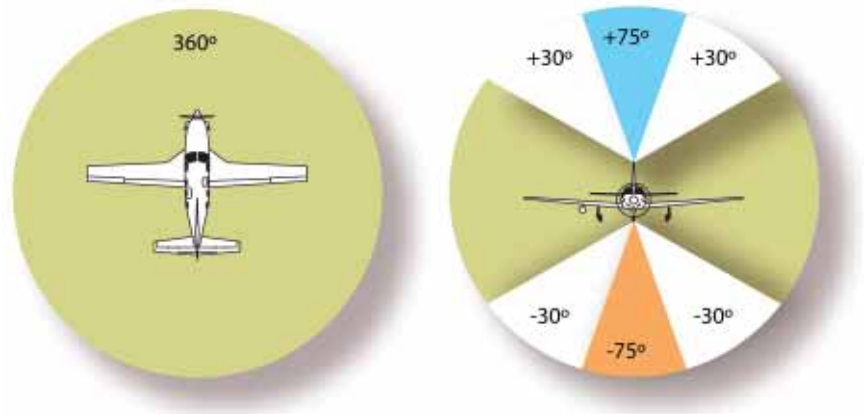
## Effective exterior illumination can help you see and be seen when flying day or night.

BY MARY BERNARD

When it comes to illumination, whether for certified planes or homebuilts, all lights are not created equal. So let's say you've reached that point in your building project when it's time to decide how you want to light the outside of your aircraft. Where do you begin? You could query the FAA's web site for the applicable regulations, but you might find yourself lost in a bog where each step gets you no closer to the information you seek, especially if you don't have a specific FAR section number at the ready. Your local FSDO might be helpful, but that could also be an exercise fraught with frustration and inconsistency. (Not all inspectors will be familiar with Experimental aircraft and the freedom they afford.)




Well, here's a bit of aid. After some legwork, we can offer a basic primer that may facilitate your aircraft lighting deliberations.




Anti-collision strobes must project light 360° around the airplane's vertical axis. Approved anti-collision systems must project light +/-30° above and below the horizontal plane of the aircraft (left). Anti-collision lights mounted on the wingtips must converge 1200 feet directly ahead and to the rear of the plane on its centerline, and if greater than that, a third light is needed.

## The Fundamentals

As with so many other aspects of homebuilding, much of the decision-making on lighting will be based on what type of flying you intend to do. If you'll only fly during daylight hours, you're off the hook—no exterior lighting is required. That's right: nothing. Nada. Zip.

The requirements change dramatically if you will be flying at night. Then, you need position and anti-collision lights at a minimum. The reasoning is that if you're up there mixing it up with other aircraft, you should all have at least the minimum allowable lighting devices installed. It's pretty hard for other aircraft to see a totally dark airplane at night.

What is the minimum? The FAA offers dissertations on aircraft lighting that include spectrometry analysis, tristimulus colorimetry and luminescence efficiency studies. (Yes, your tax dollars are hard at work.) While interesting, how much this will inform your decision-making is an open question. But once you locate the applicable FAR subsections, they do offer some guidance.

Basically for position lights you need an "aviation red" light on the left side, an "aviation green" light on the right side and an "aviation white" taillight (FAR 23.1389). Placement is critical to these lights' effectiveness. For example, if you have too much spillover from your red and green position lights, they'll cancel each other out.

Since mid 1977, a minimal anti-collision lighting system, which may include halogen, oscillating beacon or strobe, must produce a minimum of 400 ECP (effective candle power) in aviation red or white, 360° around the aircraft's vertical axis and 75° above and below the horizontal plane (FAR 23.1401). This coverage can be achieved with one or more lights.

But the minimums are just that, and no self-respecting pilot flying in busy airspace should be contented with the minimum.

Where do you install the lights? Position lights appear on the wingtips and tail, but there is more leeway for anti-collision strobes, which can go on the

Some of the lighting installations shown below might not pass muster with the FAA in terms of providing the requisite 400 ECP or in terms of offering sufficient shielding for the LED nav lights. Also, clear fairings alter the way light is distributed (due to refraction), which may prevent the lights from working the way they were intended to, resulting in insufficient coverage.



*Illustration/Photos: Steve Karp, Jeff Argersinger (Whelen Engineering), Marc Cook*

vertical fin, the wingtips, and/or the fuselage. The location is determined by aircraft design considerations, obstructions and power-supply issues. One anti-collision strobe light on the vertical fin meets the minimum requirement for most aircraft, and while it is often white, it can also be red or half white/half red. If the plane is so equipped, the strobe must be used during daylight hours, and it can't flash more than 180 times per minute, or less than 40. Keep this specification in mind when shopping for strobes meant for vehicles other than aircraft.

Above the minimum, and in line with how certified aircraft are equipped, Elizabeth Gonzalez, a technician at Aeroflash Signal, says you may want to add wingtip strobes, a red beacon on the tail, and a white flashing strobe on the belly.

Fred Frazier, vice president of the Aviation Division at Whelen Engineering Company, asks one question when making lighting decisions: How much is your safety worth to you? He concurs that some sort of ground identification light is good. "You want something that says the airplane's on and we're ready to move."

Frazier also advises installing a landing light, because being able to see what's ahead of you on the runway just seems like a good idea. What type of landing light depends on how good your eyesight is and how fast your airplane goes; the general rule, he says, is that you should be able to see 3-4 seconds ahead so that you have time to take evasive action should an incursion or other obstacle appear.

## The Choices

Once you have the minimum requirements, the next step is choosing the lights you want from the myriad manufacturers plying their wares. This isn't just a matter of matching up the light's specifications with the FAR regulation. The installation is design specific, and is dictated in part by the nature of the aircraft and its electrical system. For example, says Gonzalez, placing the power supply next to the light is recommended. However, some homebuilts lack adequate space to do this, so the power supply must be mounted in the fuselage. If you're installing strobes, this necessitates using shielded cable from the power supply to the light to avoid high-voltage interference with radios and other equipment. Frequently, though, she says, installation problems result from bad grounding or poor connections.

In addition to the traditional incandescent bulbs, one of the newer and continually evolving options is LEDs for a growing variety of applications. Frazier sees LEDs as the future of aircraft lighting, and says Whelen is proposing the development of both an LED taxi light and a landing light in addition to its existing inventory.

One advantage of LEDs, Frazier says, is that they are low draw and require lighter wiring, which is a consideration when weight is an issue. "Let's say you have an aircraft with a 30-amp alternator. LEDs are good because they draw little current." The LEDs are low noise, which means less interference potential for radios and other nav/com equipment. "High voltage equals high noise," Frazier says. The LEDs are also cool and long-lived. Although, it's a bit of a misnomer, an "LED strobe" is available, but it's really a flashing LED. "Actual strobes are high-voltage devices," Frazier said.

Another consideration is the size of the space in which the light will be mounted. Some strobes, for example, use a bayonet mount, which requires a certain depth of hole in order to be installed correctly. The LEDs don't use this type of mount, so they're a good bet when space is limited. Another plus is that the cost of LEDs is coming down even as the technology is improving. "They're getting brighter," Frazier says. "We can do with three bulbs now what we used to do with six."

Another development in recent years is HIDs or high-intensity discharge lights. Although it seems a contradiction in terms, HIDs are actually strobes that are on continuously, much like the lights used on high-end automobiles. Frazier says Whelen isn't willing to invest in the research for these at this point, and because HIDs are high intensity, they're potentially noisy.

Nope, it's not an electric boot. It's Whelen's new strobe/LED nav light unit. The lens has a built-in magnifier, and the retainer provides cutoffs for the nav light.

Three-in-one lights—forward and aft nav plus a strobe—can meet requirements with just two lamp assemblies.

## Build Your Own?

So why not just buy the individual components—bulb, lens and power supply—and build your own lights? Aeroflash's Gonzalez seemed puzzled by the question, but said she thought builders would want something that was approved and guaranteed to work. "How could they guarantee that in their garage?" The short answer is that you probably could assemble lights yourself, but you might not be in compliance with

Strobe power supplies can be centrally mounted in the fuselage or separated and located near the flash units themselves at the wingtip, as above.

FAA regs. The light assembly has to fill a certain coverage to be legal. Look for an Aero Lectrics column from Jim Weir on building your own strobes a bit later in the year.

And what about the required colors, aviation red and green? Whelen pointed out that there's more to it than meets the eye. To get an aviation red light, you start with an orange lens, because when it heats up to 300°, it gets darker and actually looks red. If it starts out red and gets hot, it will fall out of the acceptable spectrum. It's not easy being green either. That is achieved with a blue lens and a specific yellow filament so that the combined effect is green. These considerations, along with numerous FAA requirements is why "it takes about $100,000 to develop a new light," Frazier says.

But if you're slightly off the mark or out of compliance, will you really get caught? Probably not, Frazier says, but such a violation, if detected by the FAA, could ground the airplane. One irony is that even approved lighting, if it's installed incorrectly, may be out of reg. One of the trends in homebuilding, as in general aviation, is to enhance the airplane's aerodynamic performance in any way possible, which sometimes means putting a clear fairing over a light to reduce drag. If this is not the intended installation, it can affect the light's ability to do its job (because of refraction), and may well fail to comply with FAA requirements.

Another irony is that the FAA has exacting regulations for aircraft lighting manufacturers, hence the elevated cost of research and development. But once the lights are out there in the world being used on real aircraft, the oversight is more lax. "The FAA inspectors are just not that educated [about lighting]," Frazier says.

And, realistically, the regs themselves are sometimes lacking. "FAA gives you interpretations," Frazier says. "The FAA regs are ambiguous, but they're holding us to strict requirements. It should be black and white. But that's just the way it is."

It boils down to is this: Whatever you can do within reason to enhance the visibility of your aircraft is a worthwhile investment. Consider one study which showed that pulsed blue lights caused 99% of birds exposed to them to exhibit alert behavior. If only to help man and beast keep out of each other's way, let alone other aircraft, that's a benefit too significant to be taken lightly. +

## SPORTPLANES™ MARKETPLACE

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# COMPLETIONS BUILDERS SHARE THEIR SUCCESSES

## Blair L. Murray's Challenger II

This is my third Experimental aircraft, a Challenger II. Wish I had built this one first. Could have enjoyed a lot more flying time. First flight was June 27, 2006. Wow!! A delight to fly, forgiving and what a view from the cockpit. Power is a Rotax 503 with electric start. I like it so much I became a dealer. My first project was a 5151, then an Early Bird JN4D Jenny replica. I am building a second Challenger II Special in my shop with the owners. Having fun in Pennsylvania.

KYLERTOWN, PENNSYLVANIA
BRMURRAY@PENNSWOODS.NET

## Garrett Komm's GK-1

I designed and built this ultralight Corsair replica by myself from scratch in a year and three months. Not being one to shy away from a dare from a fellow pilot, I felt it was up to me to show just what could be accomplished when you put your mind to a project. I am glad to say it is a very stable and docile plane to fly. Power is from a Rotax 503, giving a cruise speed of 65 mph. It is one of a kind. Shown in the colors of Canadian war hero Lt. "Hammy" Gray, it was test-hopped on the 60th anniversary of his last flight on August 9, 1945. With over 50 hours on it as this is written, the only thing left is to retract the landing gear. Special thanks to Marilyn and all the guys at the Indus Airpark for their inspiration.

CALGARY, ALBERTA
KOMMAIR@TELUSPLANET.NET


## Joe Hutton Jr.'s R-80 Tiger Moth

February 5, 2006, was a great day. We celebrated my father's 82nd birthday, and the DAR issued the Airworthiness Certificate for my R-80 Tiger Moth. After five years of mostly weekend work totaling 1900 hours, our beautiful yellow biplane won "Best Fabric Homebuilt" at Sun 'n Fun 2006. It was also to be featured on the Outdoors Channel in an episode on aviation communities. Our Tiger Moth is equipped with dual controls and complete day/night VFR instrumentation, in order to allow flying in Florida's often congested airspaces. Due to its small 24-inch width and light 168-pound weight, the Jabiru 3300 is what we chose for power. Our airplane is decorated "per period" in the scheme of a British pre-WW-II trainer. The cowling and nose bowl are hand-formed aluminum, left natural for contrast. My biggest "Thanks" goes out to my wife, Prudence. She is the biggest supporter in this project and is likewise looking forward to watching many sunsets over the west coast of Florida very soon. Customer support from the entire staff at Fisher Flying Products, and Andy Sylvester with Suncoast Sportplanes Jabiru, has been excellent.

OCALA, FLORIDA
FLYJUMPDIVE@COMCAST.NET

Submissions to "Completions" should include a typed, double-spaced description (a few paragraphs only—250 words maximum) of the project and the finished aircraft. Also include a good color photograph (prints or 35mm slides are acceptable) of the aircraft that we may keep. Please include a daytime phone number where we can contact you if necessary. Also indicate whether we may publish your address in case other builders would like to contact you. Send submissions to: Completions, c/o KITPLANES® Magazine, 203 Argonne Ave., Suite B105, Long Beach, CA 90803. Digital submissions are also acceptable. Send text and photos to editorial@kitplanes.com with a subject line of "Completions." Photos must be high-resolution—300 dpi at a 3 x 5 print size is the minimum requirement.

# ENGINE BEAT

BY TIM KERN

## Conducting an *oil-filter* autopsy.

Last month in this space, we talked about oil-filter technology and concluded that cleaner oil is better. We also left off recommending regular oil and filter changes and echoed engine experts everywhere who say that looking inside the filter is a process well worth your time. Now we go beyond the *should* right into the *hows* and *whys*.

The purpose of an oil filter is to catch contaminants before they are allowed to run around inside your engine and do harm. For the most part, those contaminants are benign, the result of normal wear. But when things start to go awry inside your engine, often the first clues can be found inside the paper folds of your oil filter.

Opening an oil filter is an easy task often made more difficult with the wrong tools. Use a special filter cutter to minimize the mess, and to keep flecks from the can from ending up in the media.

### Getting Inside

Every step of the process yields information, so don't skip any. When you remove the oil filter, pour its oil through a white shop rag or a coffee filter—assuming there is oil remaining in the can, of course—and look for anything that stays behind. You will likely see carbon deposits (they look and feel like rough little black rocks) and possibly lead (rounded blobs or dark grey powder). These are normal, and generally not harmful. If you see anything that has bright color or shine, though, pay attention.

Like anything in aviation, there's a method to properly opening the oil filter. Filter cutters are designed to cleanly shear, rather than saw away at the exterior of the can. Using a hacksaw or bandsaw just puts chunks of metal into the mix. It's true that few engine contaminants will come out with white paint—like the outside of a Champion oil filter—but cleanliness counts.

*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.*

Carefully disassemble the oil filter, setting aside the fibrous element on a clean surface. Look in the can itself, to see if there is any buildup. Wet, grey powdery stuff is not a concern; colored powder, shiny powder, chunks or slivers may very well mean trouble. More on that shortly.

Remove the fibrous media from the spool with a serrated steak knife. Slice carefully between the edge of the media and the base of the spool all the way around. Filter media is actually a long band of pleated material joined by a metal strip. Carefully pry that strip off the end. Expand the media over your clean surface and begin looking. Typically, the heavier components will be found at the apex of the crease; remember that the filter media is mounted "dirty side in" so that the oil will be headed from the center spool to the inside surface of the can. That inside surface is where you'll see the action.

### What's in There?

Most of the time, you'll find little to worry about, but plenty to think about. You want to be aware of the overall level of wear in your engine, but you especially want to concern yourself with the rate of wear, and particularly of any change in that rate. To determine this rate, make detailed notes on what you find: a teaspoon of grey material, four flecks of ferrous metal smaller than a pencil lead, that sort of thing. Photographs can always help your memory, and it's not crazy to take pictures of every inspection.

When you examine deposits in the can or on the filter element, there are three things to look for: material, shape and size. When you know the material, you'll know where the wear is taking place. From size and shape, you will determine the source of the wear; or at least get close to it. Don't panic over

Use care to remove the filter element from the can and take a moment to inspect the inside of the can for debris and residue.

Removing the fibrous media from the holder can often be done by hand, but a serrated knife can be used to cut through the media.

Inspect each pleat inside and out. (See text for ways to identify certain wear particles.)

lead and carbon deposits. (They squish easily or dissolve when faced with solvents. Metal won't do that.)

Determine the source of the contaminants. Penn-Yan Aero's Bill Middlebrook says it's good to use a magnet to see if you're making iron or steel. Bronze and aluminum can be washed with acetone, mineral spirits, lacquer thinner or MEK. The color will give you a clue what you are looking at. If you get suspicious, don't be bashful about using magnification: anything from a magnifying glass, to a jeweler's loupe, to a microscope will help, and they are all cheaper than unnecessary engine work.

Iron and steel come mostly from piston rings, cylinder walls, cams or tappets; sometimes from wristpins, oil pumps and gears. Aluminum in the oil usually is piston material, though some engines (such as the Rotax 912) run the camshaft against the aluminum case, and aluminum in the oil may be a sign of wear in that area. Bronze is found primarily in bearings and some accessory drive gears.

## What to Do

When you find metal in your oil, consult an expert—an oil analysis house or an engine overhauler. Your local A&P can be a good source, too, but the OA houses and overhaulers usually have a lot more specific knowledge. If you find metal in your filter, put the whole mess in a plastic bag and bring it to an expert. After you have performed several oil filter autopsies on your own engine, you will know what's "normal" for it, too.

If you have big chunks (like $^{1}/_{64}$ inch or bigger), more than half a teaspoon of semi-solid goo, or anything unusual or metallic, stop flying that engine. If you don't plan to get an overhaul, at least get an expert opinion. Sometimes, the chunks are harmless (benign carbon can look like deadly metal); usually, they're not.

When something is outside the normal range, again, consult your expert. It's possible that your engine isn't dead, just sick, and it may get well on its own. Though mechanical illnesses rarely cure themselves, some do. Middlebrook cites the occasional wear that seems to go in phases, as piston pin plugs migrate. Made of aluminum or brass (or bronze), these pin locators occasionally move slightly, shaving off bits of themselves against the cylinder walls. After a short period of wear, they re-establish their clearances, and the telltale aluminum, brass or bronze deposits return to normal levels. While you shouldn't assume that a sudden aluminum storm in your oil filter came from that source, an expert may be able to determine whether it did, and save you the cost of unnecessary work. But if it gets worse, you have a problem.

## A Special Note About New Engines

There's no kind way to say this, but the first time you open the filter on a new or just-overhauled engine, it's going to be ugly. Those first few hours are when the most wear takes place, and the aftermath will show up in the filter. If it seems like the deposits are excessive, consult your engine maker or overhauler. Generally, you'll be told to change the oil, fly a bit more, and check the filter again after a short interval. If the prodigious deposits remain, then you can start working on a plan with your overhauler. It's likely you'll see deposits in that first change that you'll never see again as the lubes and sealants used when the engine was built slough off.

## Other Sources of Contaminants

If your engine suddenly starts making metal, consider some other sources. For example, a recent oil-cooler overhaul can leave nasty looking deposits, as can using a cooler that was on the engine or in the circuit during a catastrophic failure. In this case, have the cooler overhauled and use new lines. The same applies to external oil tanks on those engines so equipped.

Finally, be curious and cautious, but rational in your reaction. Don't open up an engine on the basis of one oil sample or filter inspection. If you find metal, consult the experts but also continue a course of remedial action—including a borescope inspection of the cylinders, for example—before committing the engine to an overhauler. ✚

*Photos: Courtesy Penn-Yan Aero*

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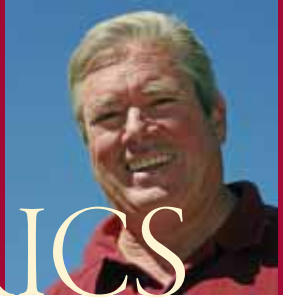


BY JIM WEIR

## It takes *brass* to make this antenna.

Prelude: This time we are going to be talking about an antenna that is intended for the summer fly-in season, and just as I started writing the article...it started to snow outside. Snurf.

If you will recall last month, I said that I was going to give you a few more cheap-'n-dirty antennas for your favorite ground station. The more I fiddled (pardon, that's heuristically experimented) with the concept, the more I remembered a few dozen times when I was called on to set up a ground station under less than ideal circumstances and usually under a tight time budget. Mostly, the call came early in the morning the day of the fly-in when somebody remembered that the office folks were going to be busy with the gas truck and nobody was going to be monitoring the Unicom. Could you get over here in the next 10 minutes, please?

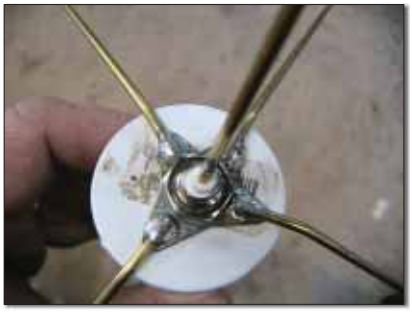
From parts to working station in about 4 minutes flat. Station range is about 2 miles; range with antenna is about 50 miles.

So I'd take the little handheld off my desk, find an old prototype antenna with a C-clamp to hold it to the car roof and off I'd go. Not exactly what we'd like to show off to our visiting pilots as the latest in technology—more like Dogpatch Unicom. So let's make an antenna that can be grabbed from the shelf, set up in less than 10 minutes, be stable in winds of 20 knots or less and look good.

Far and away, a simple ground plane antenna is the cheapest, easiest and most non-critical antenna to tune that we have. Five metal rods, all the same length, one connector and bingo: instant antenna. However, getting that antenna upside of an 8-foot mast quickly, and without a lot of fooling around, isn't all that simple... until now.

The answer is to make the antenna part of the mast. You must know by now that I'm a fan of plastic water pipe for a lot of unusual uses. However, water pipe has one un-redeeming characteristic, which is that it is ungainly and difficult to handle in long lengths. It takes up a lot of room when transporting it in 4- or 8-foot sections. However, to be a truly effective antenna, we need to get our radiating rod up well above people, automobiles and wings, which means at least 8 feet off the ground. This is going to be a water pipe and brazing rod extravaganza.

Basically, we have an H-shaped base with the antenna mast coming out of the center crosspiece of the H. The H is stable from side to side, from corner to corner and from any angle in between. I had planned originally to simply slide the pipe sections into the fittings and have friction be my friend to hold the whole thing together. However, a 15-knot wind showed me the error of my ways. With that 8-foot moment arm of the mast twisting at the T-fittings that make up the H shape, the whole thing came tumbling down. Four well-placed anti-rotation pins stopped that foolishness.



This is the drilled cap with the ground plane radials.

The H base is ready for the antenna to be mounted.

The coax exits through the bottom Tee.

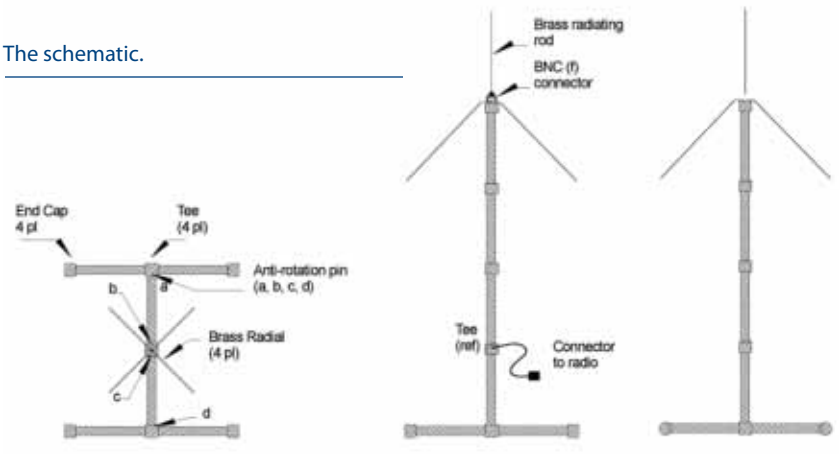
### The Ingredients

Here are step-by-step directions on how to make your fly-in special quickbuild antenna with mast.

*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*

The schematic.




Anti-rotation pins prevent the mast from turning in windy conditions.


Label your fittings to ensure the right fit when you reassemble the antenna.

Materials List:

5 each 0.094-inch brass/bronze brazing rods 22.5 inches long (hardware store)

4 each ⅜-inch hole solder lugs (hardware store)

1 each UG-1094 type BNC female chassis mount connector (Hobby Shack)

1 each RG-58 cable, 8 feet long with BNC (m) connectors on each end (Hobby Shack)

1 each RG-58 cable with BNC (m) connectors on each end long enough to reach your chosen radio location (Hobby Shack)

1 each BNC female coupler (barrel) (Hobby Shack)

10 each 1-inch Schedule 40 water pipes, 24 inches long (hardware store)

4 each 1-inch Schedule 40 Tee (hardware store)

5 each 1-inch Schedule 40 end caps (hardware store)

3 each 1-inch Schedule 40 couplers (hardware store)

4 each brass/bronze brazing rods, 3 inches long (hardware store)

## Building It

1. Drill one of the end caps with a $^3/_8$-inch hole. Countersink the hole with a half-inch bit on the inside of the cap so that there is about 30-50 mils of plastic left on the original hole size. The BNC connector should fit into this hole with the shoulder of the connector well into the countersink (you will need as much thread of the connector on the outside of the cap as you can get).

2. Grind one end of the long brazing rod down until it fits into the center pin of the BNC connector. Solder this "radiating rod" to the connector. Be generous with the solder.

3. Solder each one of the remaining four long brazing rods as a ground plane wire onto one of the solder lugs. Use a "lap joint" solder connection with the backside of the lug completely free of solder and rod. Keep the solder away from the center hole of the solder lug.

4. Insert the BNC connector/radiating rod through the inside of the drilled end cap so that the threads are sticking through the outside of the cap. Put all four ground plane wire lugs over the connector threads and tighten the lock washer and nut of the connector to firmly hold the ground plane wires. Set the antenna aside for the time being.

5. Assemble the H base, starting with the center plastic Tee. Put two 24-inch lengths of pipe into the "straight through" holes in the Tee, one coming out from each side. Onto the ends of these pipes, put another Tee at right angles to the center Tee. Put two 24-inch lengths of pipe into these two Tees to form the arms of the H. Put end caps onto all four ends of these pipes. This is the H base of the antenna and mast. Be firm about inserting the pipes into the Tees. Put a vertical pipe into the center Tee to check for verticality.

6. Drill (0.094-inch) the Tees/pipes at locations a, b, c and d as shown in the diagram. Put a short brazing rod into each of these holes to act as anti-rotation pins.

7. Onto the vertical pipe in the center of the H, put another Tee. Run the coaxial cable through this Tee and out the top.

8. Run the coax through another section of pipe, another coupler, another section of pipe, and so on until the four sections of pipe form a mast 8 feet high.

9. Attach the BNC (m) cable coming up the mast to the BNC (f) connector inside the end cap that forms the antenna. Put the end cap on the top of the mast and you are done.

Hey, wasn't that more fun than a human should be allowed? In the coming months we are going to talk about LED replacements for nav lights, strobes and a whole bunch more. Stay tuned.

# WIND TUNNEL

BY BARNABY WAINFAN

## *Safely* executing a go-around.

Last month we began our discussion of slow flight with a look at the aerodynamics of flying slowly, and how this affects the airplane in the traffic pattern and on the approach to landing. Sometimes, however, an approach goes wrong in a way that makes a safe landing difficult or impossible. This can happen because of a poorly executed approach, leading to the airplane being too high to land safely without overrunning or being laterally offset from the runway. The pilot cannot align the flight path with the runway without doing a dangerous amount of low-altitude, low-speed maneuvering.

The pilot may execute a perfect approach and be forced to abandon the landing because of other factors like an intrusion onto the runway by another airplane, an animal or a ground vehicle. A sudden atmospheric disturbance such as a very strong wind gust or wind shear can also ruin an otherwise fine approach.

In any of these situations, the pilot must execute a missed approach or "go-around." In so doing, the airplane must transition safely from a gliding descent towards the runway to a full-power climb.

### Going Around

After the base-to-final turn, the pilot slows the airplane to approach speed and configures it for the approach and landing. The airplane is typically in a high-lift, high drag configuration. The flaps are down and at or near maximum deflection. The landing gear is extended, and the engine is throttled back to near idle power.

During the majority of the final landing approach, the airplane is flying at about 1.3 times its stall speed. For the airspeeds and approach slopes typical of light airplanes, this leads to a descent rate of 300-500 feet per minute. For some airplanes, this sink rate is higher, and can exceed 1000 fpm.

A go-around appears simple at first: Simply add power and fly away. In fact, there is a lot more happening than meets the eye. In order to go around, the pilot must arrest this descent rate, establish a positive rate of climb, and clean up the airplane aerodynamically so that it can climb away. All of these actions produce effects that require attention to keep the airplane under control.

### Power Up

On approach, the engine is at or near idle power. To climb away, full power is needed, so the first action a pilot takes to initiate the missed approach is to add throttle. Increasing power at approach speed has several significant effects. The first desirable effect is that the airplane will begin to accelerate, and the rate of descent will slow somewhat. There will also be some significant trim and controllability effects that the pilot must attend to.

Low airspeed—during takeoff, landing or go-around—means that the control power of the flying surfaces is reduced, so larger inputs will be needed.

Some airplanes exhibit large changes in pitch trim when full power is applied in the approach condition. This is particularly true of airplanes that have effective flaps in the propeller slipstream. The increased airspeed over the flaps induced by the propeller increases

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

*Photo: Kevin Wing*

the lift of the flaps, increases the nose-down pitching moment the flaps produce, and also changes the downwash from the flaps that impinges on the horizontal tail. The relative strength of these effects varies from airplane to airplane, but often the tail downwash effect dominates and causes a strong nose-up trim change when power is applied. Because the airplane is already flying slowly, it is important for the pilot to oppose this nose-up trim change and not allow the airplane to slow down further in order to avoid a stall.

If the airplane has a single engine, there will also be a significant yawing moment due to the P-factor caused by the additional power. The pilot must oppose this yawing moment with rudder to maintain control and keep the airplane in coordinated flight.

As we saw last month, lower airspeed means that the control power of the flying surfaces is reduced. Accordingly, the amount of rudder needed to keep things under control in a go-around may be quite large. If the airplane has enough power, it might not have enough rudder power to maintain control at full power. This is the case for many WW-II piston-engine fighters, and also for some of the higher-power homebuilt singles. A significant number of accidents have been caused by the pilot losing control when applying full power at low airspeed, and then running out of rudder to oppose the yaw caused by the high power. If the airplane has the potential for this kind of problem, the pilot must first apply partial power, and then add more power once the airspeed has risen to the point where the rudder is powerful enough to maintain control.

## Pull Up

Once power has been applied, the next step in the go-around is to pull the nose up to aim the flight path away from the ground and establish a climb. This pull-up should be a smooth maneuver rather than an abrupt one. It is important to make sure that the pull is gradual enough so that the airspeed remains constant, or starts to rise. The airplane is flying slowly when the pilot initiates the go-around, and allowing it to slow down any more could have serious consequences.

First, the airspeed is relatively near stall speed, so allowing it to drop too much can stall the airplane. Second, allowing the airplane to slow much below approach speed will place it on the back side of the power curve, where drag increases with decreasing airspeed. This increased drag will hurt the airplane's ability to accelerate and climb. In extreme cases, usually involving a combination of high gross weight, large flap deflection and high/hot conditions, it is possible to slow an airplane to the point where it will not climb at full power unless the pilot first drops the nose and gains airspeed. In such a flight condition, the pilot cannot arrest the sink rate of the airplane without first losing additional altitude to gain airspeed. If this happens at very low altitude or in a situation where the airplane must clear an obstacle, the result can be unfortunate for all concerned.

## Clean Up

Once the sink rate has been arrested and the airplane is gaining airspeed, the pilot must then configure the airplane for climb. In general, this means raising the flaps and landing gear. Both of these must be done cautiously.

In general, it is unwise to retract the gear until the airplane is clearly established in a climb. There are two reasons for this. First, if the go-around is initiated at low altitude and low airspeed, the airplane is likely to continue to sink for a few moments after the pilot applies power. It is possible that the airplane will briefly touch down before climbing away. If the gear is down, this is not an immediate problem. If the gear is either retracted or in transit, the most likely point of first contact with the ground will be the prop rather than the landing gear. At best, this will damage the prop tips, and make the subsequent trip around the pattern a nervous one. At worst, it will kill the engine and lead to an unplanned gear-up landing and aftermath.

Another consideration is that, though the airplane will have lower drag with the gear fully retracted than it does with the gear down, it may well have higher drag with the gear in transit than it does gear down. The retraction sequence on some airplanes incorporates things like opening doors that are closed with the gear down or, as is the case with the high-wing Cessna retractables, the gear legs will rotate during the retraction sequence so that the wheels are flying sideways through the air for a while as the gear cycles. This temporary increase in drag can be a problem if the gear is cycling just as the airplane is at its minimum airspeed, and the pilot is trying to get the airplane to accelerate and establish a climb.

Flaps should be retracted gradually. Highly deflected flaps produce a lot of drag, but they also produce a lot of lift. Retracting them reduces drag, but is also reduces lift momentarily, until the pilot can compensate by increasing angle of attack. Retracting flaps suddenly can cause the airplane to sink quite a bit and, if the airspeed is too low, cause a low-altitude stall. On high-power airplanes this is not a big issue, because the airplane has enough power to climb acceptably with the flaps down. On some lower-power trainers the rate of climb with full flaps is marginal at best, so the pilot must maintain altitude, but not be aggressive about trying to initiate a climb until the airspeed has increased enough to allow the flaps to be partially retracted without stalling the airplane. Once the first 10-15° of flap retraction is accomplished, the airplane will begin to accelerate much better, and it will soon be possible to completely retract the flaps and establish a normal climb. ✚

# LIGHT STUFF

BY DAVE MARTIN

## Does the *Sebring Expo* point to LSA's future?

From the outset of the movement toward the Sport Pilot license and Light Sport Aircraft in the mid 1990s, detractors noted the outcome of an earlier attempt at lower-cost sport aviation. The Recreational Pilot license and associated Recreational Aircraft category of the early '90s were a resounding flop: Only a few dozen Rec Pilot licenses were issued, and few copies of the three FAA-approved Recreational Aircraft were sold.

By comparison, the newer Sport Pilot/LSA program is wildly successful with close to 1000 Sport Pilot licenses already issued and 46 LSAs already FAA-approved for factory-built, ready-to-fly status. Everyone acknowledges that market saturation is likely to whittle the number of LSA manufacturers and importers, but with already flying prototypes from long-established brands in the game such as Cessna (with its factory-built SLSA) and Van's Aircraft (with its RV-12 LSA) optimism is high.

Other positive indicators are EAA's seven-stop nationwide Sport Pilot/LSA tour completed last fall and continuation of the LSA Mall that will be stage center again this summer at AirVenture.

### The Sebring Connection

Yet the best indicator of how far the new category has come since its official opening in September '04 may be the LSA Expo, held in January for the third year at Sebring, Florida. Exhibitors and attendees were up almost a third from last year's Sebring show. Virtually all factory-built LSAs were represented at the four-day event that began on January 11, and some were there in quantity. American Legend Aircraft brought four of its Cub-like airplanes, and many other companies displayed and flew three to six aircraft.

The Expo is different. For one thing, it's not a fly-in; it's an outdoor showcase of LSA-related products and services. Bob Wood, chairman of the Sebring show (officially, it's the U.S. Aviation Expo), makes clear another difference between this event and larger shows. "A major objective," he said, "is to be a good host to exhibitors. The way to build a show is to attract exhibitors. The rest of it will come."

An example is the emphasis on flight demonstrations with prospective customers. Many other shows prohibit or greatly restrict the time and location of demonstrations and sales-related flights. At Sebring, such flying is encouraged, and most aircraft companies brought one or more demo aircraft. Dedicated special runways and patterns for LSAs were in use all day when wind conditions permitted, which was most of the time. No accidents or incidents were reported during the four-day Expo, and well over 500 demo flights were completed. Pilots were assisted to keep things moving quickly and safely by volunteer "controllers" with paddles and hand signals, as at the big shows.

*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.*


The number of visitors and exhibitors continues to grow at the Sebring Expo.

Bob Wood leads 250 volunteers at the highly successful show.

Wood and the organizing committee—all of whom are unpaid so far—have attended all of the big shows. "We talked with every potential exhibitor with something for the LSA community, whether it's Garmin or Lowrance or an airplane," he said. Garmin and Lowrance were both represented.

Exhibitor space of 40x40 feet on concrete was $500 including tiedowns, a tent, a table and two chairs. "Those things are expensive," Wood said. "We wanted to avoid requiring exhibitors to bring or rent tents."

A first-night party for exhibitors included a reception, heavy hors d'oeuvres, wine, beer and music. Friday night there was a dinner for volunteers and their guests hosted by a new



*Photos: Dave Martin*

supermarket and featuring a speaker. About 250 attended.

Initially, the Sebring Expo was a non-profit corporation set up under a Chamber of Commerce charter. Starting this year, the event is organized as an S corporation with seven shareholders. "Each member has put in some money," Wood said, "and nobody is on a payroll. The staff will be motivated to get this thing going—maybe for several years—without getting paid." Money that would be spent on payroll taxes and fringe benefits is being poured back into benefiting the organization, he said.

## Results

The Sebring Expo formula seems to be working. About 70 aircraft vendors attended, bringing 125 aircraft along for display and demonstration. A total of 114 exhibitors signed up to be there. Three large tents accommodated inside booths, mostly with aviation products and services. Forums were held in nearby hangars. Weather was good this year, and people liked what they saw.

Attendees paid $5 for parking and $10 or less for admission. They found ticket lines reasonably short and enough salespeople at the aircraft display spaces and the tent booths on opening-day Thursday and on Friday to answer their questions. Saturday was considerably more crowded, and on Sunday the crowd thinned again.

Numerous aircraft made their first Sebring appearance. One was the Infinity Commander powered parachute, which just received its FAA LSA approval. The company intends to produce both factory-built and almost-ready ELSA kits. Other newcomers included the T-tail Dova Skylark, the Brazilian-made Seamax amphibian (expecting FAA LSA certification this year) and a new weight-shift model from Delta Trikes Aviation.

Also on the new list were Avia's A-16 Sport Falcon, the Apollo Fox and Fantasy Air's Mystique. IndUS showed parts for its new IndUS Thorpedo T211 LP that will raise airspeed. Most of these

aircraft were seen in the air.

Cessna's prototype Sport LSA made its first public-event flights while we watched from the ground. Lacking both a completed interior and a production decision from Cessna's parent company (Textron), the Sport attracted continuous crowds. The considerable cadre of yellow-LSA-shirted Cessna employees even permitted admiring potential customers to touch the aircraft. One employee agreed with me that the question of the week was, "When does the Textron board of directors meet next?" At press time, no production go-ahead had been announced, but everyone expects it to happen.

Several engines also made their Sebring debuts, including Vulcan Aircraft Engines' four-cylinder inline diesel and UL Power's UL260i from Belgium. As at other events, EAA provided free Sport Pilot student certificates during most of the Expo.

Talk overheard in the food court tent indicated that some people came to help them decide *which* LSA to buy, not *whether* to jump in. Several companies verified the buzz, noting that they had taken multiple orders at Sebring.

## Collecting Impressions

While at Sebring, I flew five different LSAs new to me, and I plan to feature them one at a time in this column in future months. Among the most interesting is the LSA version of the Italian-built Sky Arrow line that has been available for more than a decade as a factory-built airplane in Europe and as an amateur-built kit in the U.S. An especially interesting feature in the Sky Arrow 600 LSA is availability of an approved, easily installed and removed hand control for pilots without the use of their legs. Look for some comments on that in a future column.

Next year's Sebring Expo is scheduled a week later—January 17-20. And here's a travel tip for those arriving by airline: Using Orlando instead of Tampa should shorten drive time considerably. Event details will be found at www.sport-aviation-expo.com. Expect to be impressed by what's on display and by the event itself.

The Brazilian Seamax should receive its LSA certification this year.

Rigged for test flights—note the articulating boom pitot head, foreground—the Cessna Sport flew at a public event for the first time.

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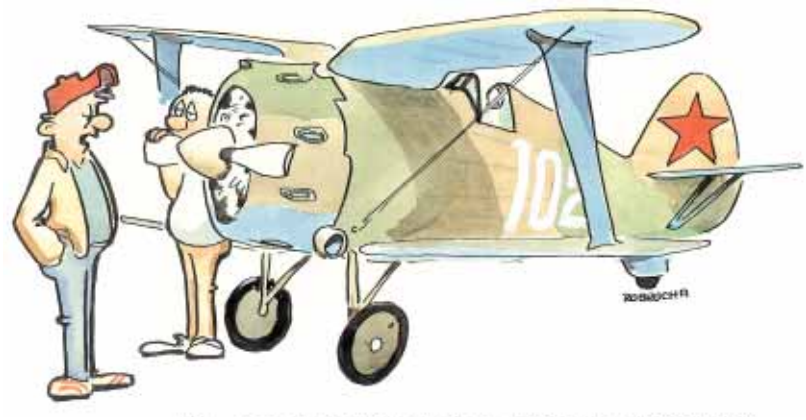

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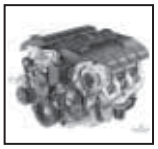


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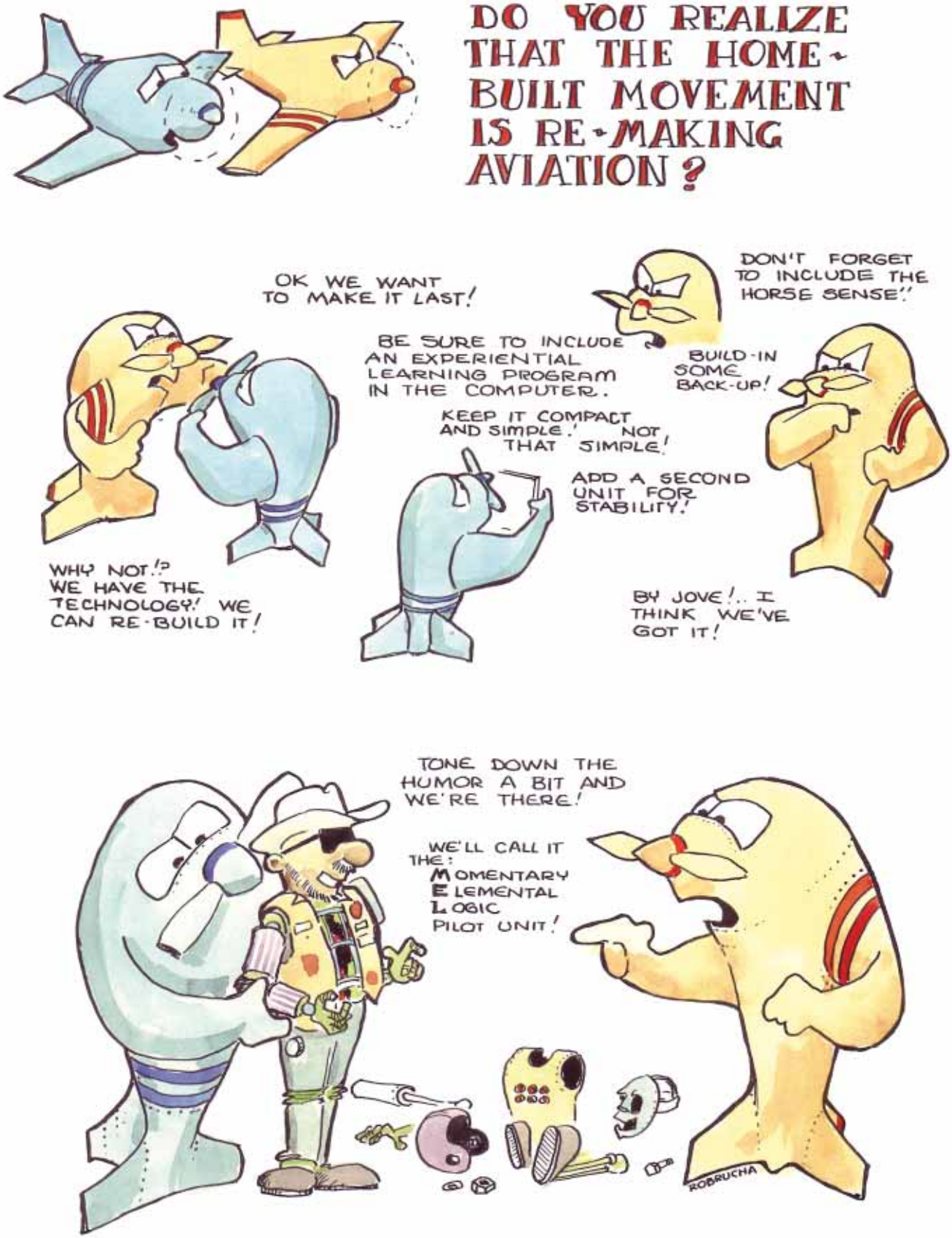

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