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CONTENTS

August 2008 | Volume 25, Number 8

On the cover: Richard VanderMeulen photographed the turbine Murphy Moose at Lakeland, Florida.

Flight Reports

8 **THE ULTIMATE AMPHIB**
Rick Orchard's one-off turbine Moose is big, capable, superbly built and, best of all, a boatload of fun; by Doug Rozendaal.

18 **THE STAAKEN Z-21A FLITZER**
Lynn Williams' modern period piece allows you to indulge your Walter Mitty leanings; by Bob Grimstead.

Builder Spotlight

30 **BUILD YOUR SKILLS: FABRIC**
Choosing the "right stuff" for your project; by Ron Alexander.

36 **ALL ABOUT AVIONICS**
Steam Gauge Special: In a world awash in electronic instruments, there's still a place for old school; by Stein Bruch.

43 **FOUND FROM SPACE**
GPS tracking technology can help loved ones keep track of your journey; by Sam Buchanan.

52 **CONTINENTAL PUSHROD TUBE MODIFICATION**
Resigned to a leak-free engine; by Ron Darcey.

68 **COMPLETIONS**
Builders share their successes.

Shop Talk

24 **SETTING UP SHOP**
Think you don't have enough room? Here's how to make the best of what you have; by Bob Fritz.

71 **AERO 'LECTRICS**
Optics 101: We start the LED nav light series; by Jim Weir.

Designer's Notebook

58 **WIND TUNNEL**
Directional stability and flight performance; by Barnaby Wainfan.

Exploring

2 **AROUND THE PATCH**
Velocity, maintained; by Marc Cook.

6 **WHAT'S NEW**
A new diesel LSA debuts, and more; edited by Mary Bernard.

47 **FIRE IN THE HOLE**
Is an extinguisher just extra weight or an essential part of your aircraft systems? By Bob Fritz.

69 **DAN'S WORLD**
I'm an amateur and loving it; by Dan Checkoway.

73 **LIGHT STUFF**
Meet the all-metal Gobosh G700S LSA; by Dave Martin.

Kit Bits

4 **CONTRIBUTORS**
5 **LETTERS**
64 **LIST OF ADVERTISERS**
65 **BUILDERS' MARKETPLACE**
75 **THE CLASSIFIED BUILDER**
80 **KIT STUFF**
Drawing on experience; by cartoonist Robrucha.

KITPLANES
THE INDEPENDENT VOICE FOR HOMEBUILT AVIATION

Velocity, maintained.

Mergers and acquisitions are the way of the world in big business, but they can be the kiss of death in our tidy kitbuilt nation. Often, though certainly not always, the new investors, owners or caretakers come in with expectations of volume generally not attainable or sustainable—or an unrealistically optimistic perception of builder independence. In short, they buy into a program that's harder to keep running than it should be.

When, shortly after Sun 'n Fun, Velocity aircraft announced it had been purchased and would become a subsidiary of the Rocket Racing Group, I among others let out a low whistle followed by a "well, there goes that company" observation. In the great tradition of hangar gossip, this summation came without a shred of evidence or even a syllable from the company itself.

I was delighted to hear from Velocity's Ken Baker with details of the acquisition and a look forward to how life is supposed to unfold in Sebastian, Florida. "Well, it's been no secret that the company principals—Duane Swing and Scott Baker—have been trying to find a buyer for Velocity. Duane, for one, simply wants to retire," Baker told me. Velocity had an interested buyer who, through a convoluted chain of events, led to the Rocket Racing Group gaining interest in the company. Already, Velocity had been tagged as the airframe supplier to this innovative air-racing series—scheduled to have its first demonstration at Oshkosh this year—and so, as Baker tells it, RRG decided that Velocity would be a good investment.

So how's this baby going to look with a rocket engine on the backside?

The deal was completed the day after Sun 'n Fun closed. "I was really biting my lip," said Baker. "I wanted to get the word out but we didn't quite have everything ready until after the show."

Great, fine. So what's the upshot for Velocity owners, current builders and prospective customers? "Rocket Racing approached [the purchase] like a smart person; they know what they don't know. So we have long-term employment contracts for the whole upper management." These contracts will keep the brain trust in place for at least the next three years. Velocity also has the benefit of a new, full-time Executive VP of Sales, Don Hauck. "He's been great. We have had to juggle sales activities with other things like giving demo rides. Now he can concentrate," said Baker. "Our sales have been good, not horrible, but they could always be better."

Looking ahead, Baker sees good things. "The Velocity, like a lot of homebuilts, is based on artisan craftsmanship—one airplane built and then molds taken off that. Rocket Racing is going to bring in a whole laser scanning crew so we can digitize the airplane, render it in 3-D. That will help us create new documentation and develop future models from CAD." Baker also thinks the company has the fiscal wherewithal to develop entirely new models, even to consider certifying them. But that's well out on the horizon, he said.

The viability of Rocket Racing as an entertainment device remains to be seen, but the future of Velocity seems to be considerably rosier than I first thought. I'm rarely upset to be proven wrong in this regard.

Those Crazy Fokkers

Dick Starks will have a new collection of his work on sale at Oshkosh this year. I've had a peek at the manuscript and can only say that Starks officially owes me a new computer keyboard. And maybe something for the pain and suffering caused by coffee expelled through the nose. *Fokkers At Six O'Clock* is a made up of new material as well as features that have appeared on these pages, and continues his delightfully meandering retellings of vintage events, flying these charismatic WW-I replica fighters and tomfoolery in general. Dick's manuscript not only forced me to Windex my poor iMac's screen, but helped remind me why we fly in the first place. Check out *www.kcdawnpatrol.org* for more info.

Marc Cook *has been in aviation journalism for 20 years and in magazine work for more than 25. He is a 4000-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: Richard VanderMeulen

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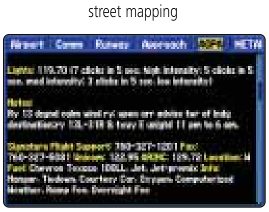

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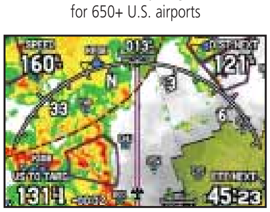

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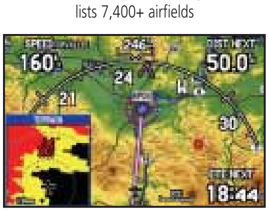

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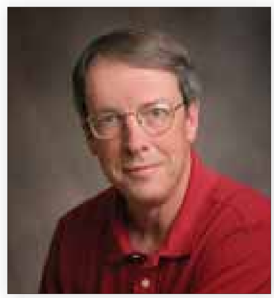
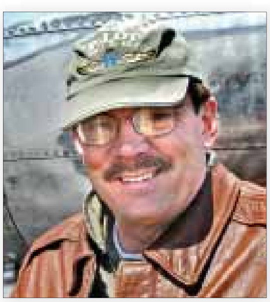
RON ALEXANDER

Ron Alexander has been part of the homebuilding scene for decades. He began restoring aircraft in the 1970s but was frustrated by the support structure—or the lack of it. He founded Alexander Aeroplane Company, which was sold to Aircraft Spruce in 1995. Ron also founded the SportAir workshops and has worked closely with Poly-Fiber. To say he knows fabric is an understatement. The second installment of our "Build Your Skills: Fabric" series begins on Page 30.

SAM BUCHANAN



Sam is an instrument-rated private pilot, flying since 1992, and he has documented the construction of his Van's RV-6 (N399SB), which took place from 1997-99, on his web site, *thervjournal.com*. The RV-6 was his third homebuilt aircraft project. He recently acquired a ham radio license to operate an APRS tracker as KJ4CKK. He now runs APRS iGate for the benefit of North Alabama airborne pilots with trackers. His story about building your own APRS tracker begins on Page 43.



DOUG ROZENDAAL

You have to know the laconic Rozendaal to appreciate his response to flying the Moose turbine conversion. "Man, that was *soooo* cool," he said, his voice crackling over the cell phone at Sun 'n Fun. That's high praise, too, from a pilot who has flown a great many high-performance (and turbine) aircraft in his distinguished career, including a long list of hairy-chested warbirds. His flight review of the turbine Moose begins on Page 8.

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LETTERS

EDITORIAL@KITPLANES.COM

Alternator Reality

In the wiring diagrams in the article "All About Avionics: The Electric Airplane" [May 2008 KITPLANES®], the alternator is shown with a fuse between its output and the bus. The diagrams do not show the voltage regulator (VR), but in the text it is said to be an external type with over-voltage protection for use with the SD-20 alternator. I assume that the field supply circuit shown going to the alternator is to the not-shown VR.

If the fuse or circuit breaker in the alternator output opens, the bus voltage will decrease, as it no longer gets the charging current and is now on battery power only. The lower bus voltage will, in turn, cause the voltage regulator to apply current to the alternator field. This current will cause increased depletion of the battery's charge, but with an added consequence: The field current will rise to maximum, and the alternator output with no load will rise to a very high voltage, often in excess of 100 volts. If a circuit breaker is used and it is reset, there will be a very high voltage spike put on the bus, which could damage the avionics.

I recommend that those using an overload protection device, such as a fuse or circuit breaker in the alternator output, connect the VR field source to the alternator side of the fuse/circuit breaker and not the bus side. That way the VR will keep the alternator in regulation and remove the field drain from the battery.

PAUL LIPPS

Fire in the Hole

At the recent Reno Air Races, a biplane had an engine fire and crashed, killing the pilot. I was crew on a Formula One racer in 1995 when Rick Brickert had an engine fire in the Pond racer. He too crashed and lost his life. A friend lost his friend due to an engine fire in a VariEze.

As long as we have carried gas or kerosene in our aircraft, we have had fires.

I was a light plane pilot for 10 years, designed structure on the Ted Smith (Piper) Aerostar and was a flight instructor, and the subject of engine fire extinguishing *never* came up. I first heard about it in ground school at TWA on the 727. It seems that the FAA and NTSB only require fire suppression equipment for large aircraft. So they want to protect large groups, but not you, your friends and family or the house you flew into!

I had been with TWA for seven years when I started designing and building a homebuilt aircraft. It was a tandem two seat, shoulder wing, mid-engine pusher, with a 5-foot driveshaft to the prop at the tail. I was worried about fire, because it was continually talked about at training. First, I needed a detection system to alert me. I used a probe from the Aerostar and bought from Piper, Radio Shack lights, horn and test button. I looked for a race car extinguishing system and found a three-nozzle system with 7.5 pounds of halon.

When I designed the aircraft, which looked like a shoulder wing F-4, I talked to Molt Taylor about using his Mini Imp drive shaft system with my Lycoming O-320. He said it would be good. It was not! After eight years, 22 flights, and 10 hours, the coupling failed at 3000 feet, east of the airport. I got to the airport, but a quarter-mile short of the runway. The best thing I did was call "Mayday." When the wreckage stopped, I was trapped due to the bent canopy locking pin. A sheriff heard my call in his hangar and ran to me, getting me out. I feared burning up in my aircraft! When I got out, there was about a 5-foot diameter fuel spill under the engine. I think the discharged fire bottle saved my life!

It is time *all* homebuilt and certified aircraft carry these systems, just as ELTs are required.

STAN BURAK

For more on built-in fire extinguisher systems, see our story on Page 47.—Ed.

Len Us Your Ear

Your May column on Experimental/Amateur-Built rules ["Around the Patch: Commercial assistance, quickbuilds... babies & bathwater."] begs the question: What is the FAA's role as assigned in law enacted by a vote of our elected representatives? In a word, its role is safety.

The current and proposed wording of FAR 121.91 (g) and accompanying Advisory Circulars is not in keeping with that assigned role. Regulations written to address safety would try to ascertain *how* a plane was built. They would present guidelines focused on structure, building practices, weight and balance and general airworthiness. Any limitations for a homebuilt aircraft would be based on physics, physiology and aerodynamics.

Today's regulations ask *why* a plane was built and *who* built it. Asking the first question is an inappropriate function of government. If the Administrator had an infallible mind reader, would any of us pass the criteria of building "solely" for our own education or recreation? Asking the second question sends rulemakers on an exercise in the pretzel logic of trying to define the meaning of "fabricated." Both questions have a history of generating paranoia. Neither fosters the safe design, construction and operation, which should be mutual goals of the government and the builder.

We must address this issue in a way that holds the FAA to account in carrying out its assignment to make rules that ensure safety. If we lose sight of that overlying framework and accept anything less, we will be revisiting this topic in another decade as technology changes the means of fabrication. We will stunt innovation to the extent that the rules discourage new and better designs. We will also fall short of doing our part to establish a principled and logical standard that promotes safety in Experimental aviation.

LEN FOX

First Diesel-Powered LSA Is Introduced

IndUS has debuted the first Light Sport Aircraft powered by a diesel engine. The proof-of-concept Thorpedo DP uses the innovative Wilksch Airmotive WAM-120 turbocharged three-cylinder, two-stroke, liquid-cooled engine, which burns 3 to 3.5 gph of Jet A fuel.

The WAM ASTM-compliant diesel engine has been flying in a Thorp T211 in England for almost four years and has logged 400 hours, says Ram Pattisapu, president and CEO of IndUS. "At 14,000 feet, it's still climbing at 500 fpm," he says.

The WAM 120 engine provides 120 horsepower and is expected to yield significant cost savings as well as increased TBO intervals, which are estimated at 3000 hours. The company plans on certifying the diesel-powered Thorpedo by this summer.

"There are many places that have no 100LL at all, or if they do, it's significantly more expensive than jet fuel," says Pattisapu. "The new Thorpedo DP will be incredibly valuable to pilots all over the world."

Orders for the Thorpedo DP are being accepted for deliveries later this year. The estimated cost is $125,000 for a night VFR equipped aircraft. For more information, call 214/337-6387 or visit *www.indusav.com*. A direct link can be found at *www.kitplanes.com*.

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Stafford Manufacturing offers a wide selection of mounting collars that can be used to attach a variety of devices and accessories onto structural tubing frames without drilling or gouging.

The universal mounting collar features a smooth bore and clamp-style design that tightens securely onto structural tubing and shafts without damaging them, the company says. It has two opposed flat sides with countersunk drilled and tapped holes, and can be easily adjusted using a hex wrench. It's also capable of withstanding more shock and vibration than radiator clamps and other mounting products, according to the company. The collars come in inside diameters of ¼ inch to 1.25 inches and are made from aluminum, steel and stainless steel with optional PTFE bushings where required. Specials including hex, square or threaded bores are optional, as is chrome plating.

Prices depend on material, size and quantity, and are available upon request. For more information, call 800/695-5551 or visit *www.staffordmfg.com*. A direct link can be found at *www.kitplanes.com*.

AirGator Offers Improved Handheld EFB

AirGator has announced the release of its improved NAVPad5 electronic flight bag. Its small form factor offers all of the functionality of the company's full-size commercial EFBs in a handheld package. Features include a 4.8-inch sunlight-visible touchscreen, fast CPU, long battery life, Bluetooth and WiFi wireless, solid-state drive (with optional hard drive), top hat, optical pointing device, Windows XP OS and a full keyboard. It's an ideal moving map, XM Wx weather display and approach viewer, the company says.

The NAVPad5 can be run in either landscape or portrait mode and, weighing just 1 pound and measuring 6.7x3.25x1 inches, it fits in virtually any cockpit.

The NAVPad5 alone is $1000, as a NAVAir approaches viewer for $1250, or as a complete Bluetooth XM Wx and NAVAir EFB moving map navigation system for $2495.

For more information, call 914/666-5656, Ext. 2, or visit *www.airgator.com*. A direct link can be found at *www.kitplanes.com*.

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FLIGHT REVIEW

the Ultimate Amphib

Rick Orchard's turbine Moose is big, capable, superbly built and, best of all, *a boatload of fun.*

BY DOUG ROZENDAAL

The infectious Rick Orchard grin is right at home in his hot rod amphib.

The relationship between sailboats and airplanes is a strong one. Anyone who has ever hauled in the mainsheet on a sailboat knows the feeling of immense power the moment that big vertical wing achieves its critical angle of attack and begins to develop lift. The boat heels (rolls) downwind, and begins to accelerate forward. The tension on the mainsheet increases exponentially. Man has experienced that feeling for thousands of years, and it is a small wonder that we did not achieve flight hundreds, if not thousands, of years sooner.

Sailors are sprinkled liberally among the pilot population and vice versa. Rick Orchard, a sailboat racer, was introduced to flying when two pilot members of his racing crew convinced him to try it. Orchard bought a Bonanza, but was still drawn to the water. A trip to the Jack Brown seaplane base for a float rating, and he was hooked. That was 11 years ago. I met Orchard this spring at Sun 'n Fun, under the wing of his turbine Moose on amphibs, N24GR, an airplane that embodies his deep affection for float flying and his ability to get a grand-scale project done in record time to a high level of craftsmanship.

What's With All the Teeth?

Orchard was wearing a cap that said "Grin Racing." That is the reason for the Gulf Romeo in the N-number, and it's the name of his sailboat racing team. The source of the team name seems logical: Orchard sports a mischievous grin that betrays his effort to look calm and relaxed. His mission-oriented approach to everything was obvious early, and as the story of the turbine Moose unfolded, it was confirmed.

On December 20, 2006, a Murphy Moose kit bearing the serial number 302 arrived outside Atlanta, Georgia. Eleven months later, to the day, November 20, 2007, the airplane flew off the land on its amphibious floats and made

Photos: Richard VanderMeulen

its second landing—on the water. You read that right: 11 months. How did they do it?

Orchard teamed up with veteran builder Doug Ripley, and together they worked full time to complete the airplane. Orchard had retired from a career in the cell phone communications industry. Much of his work was in project management, and those skills were useful and tested in the quick completion of the airplane. His original goal was to have the airplane ready for AirVenture. Ripley's standard response was, "What year?"

Project management in corporate America involves strict timelines with accountability in accordance with delivery schedules. Orchard surmised that, "The suppliers in the homebuilt industry have problems with dates." That aspect proved frustrating for a highly motivated former corporate executive working on deadline.

Why a Moose?

Orchard's previous seaplane was a BushHawk on Aerocet 3400A amphibs. It's a certified airplane built in Canada. Flying into the outback of British Columbia with his floatplane buddies, Orchard and his BushHawk, because of its size, hauled the gear. Orchard's friends in their Super Cubs would drop into little lakes where the bigger and heavier BushHawk couldn't get out. "I lusted for a turbine Beaver, the dream airplane for a bush guy," Orchard said. "When you research the market, there isn't much else out there to build (in that class) except the CompAir, and I wanted to build a metal airplane."

So the next question might be: Why a turbine? "The simple operations, the reliability, and a floatplane with reverse has lots of applications," Orchard said. Then he grinned and added, "Besides that, turbines sound cool." The decision was made: a turbine Moose on amphibs. It had been done before, but that airplane was destroyed in an accident. The Moose kit was ordered, delivered, and the race to fly began.

Orchard enjoyed the building process. "What is cool about it is, it's metal work, fiberglass work, electrical and plumbing work," he said. "Just when you get sick of one thing, it's done and you move on to the next." To build a big airplane like this in 11 months, there was little time to get sick of anything.

"There is a wide variety in the documentation of kits. The Moose kit is just a bunch of big parts. It's pretty much up to the builder to decide how to put them together," Orchard said. He and Ripley relied heavily on the support of other builders. "They all shared their experiences. It's not an exotic airplane, so we looked at the Cessna 185 and Caravan [for possible solutions]."

Even though the airplane is straightforward, adding a turbine engine and amphib floats complicates the process. Neither Orchard nor Ripley had any previous turbine building or operating experience, and that showed up in the starter switchology—more on that later.

Floating the Idea

They used the Aerocet 3400A floats from Orchard's BushHawk. One of the challenges about floating an airplane for the first time is getting the floats' center of buoyancy and the airplane's center of gravity in the right place so that the airplane flies and floats well. They gave their weight and c.g. estimates to Keith Kinden of Montana Floats, who designed and built the rigging. It all fit perfectly on the first try.

The turbine engine package came from Aerotek Aviation of Quebec City, Quebec. The firewall-forward started life on a C-12, a military version of a Beechcraft King Air 90. The engine is a Pratt & Whitney PT6A-20, an early version of the venerable PT6A. Later King Air 90s were upgraded to the -21, which would develop its 550 horsepower at higher altitudes and in hotter weather. The Moose is so overpowered that even on the hottest days, on the highest lakes, power should not be a problem.

Orchard and Ripley did a great job of making the engine look like it was meant for the Moose. Turbine conversions always involve moving the engine forward to compensate for the lighter weight of the engine, and sometimes these airplanes take on a Pinocchio appearance. This setup passes the TLAR test, "That looks about right." The King Air forward cowl transitions nicely into the custom boot cowl. The exhaust stacks were extended to prevent soot buildup on the fuselage. The King Air engine mount was modified to attach

to the firewall mounting points of the Russian Vedeneyev M-14P radial engine originally intended for the Moose. An additional attach point was built that connects the engine mount to the windshield bracing, which carries up to the front spar attach points.

One of the biggest challenges was heating and ventilation. The turbine has plenty of bleed air for heat, but it has to be cooled and controlled. That involved valves and intercoolers. Fresh air is also a challenge. Bringing in air from under the airplane brings water along; on the side of the fuselage there is exhaust, and on the top there is rain. The solution was found by bringing air in from the NACA ducts under the engine.

Extended wingtips add 20 inches of span, making room for 20-gallon auxiliary fuel tanks for a total capacity of 160 gallons, and together with a huge cabin create an airplane that could easily be overloaded despite the turbine installation, which itself makes the airplane roughly 60 pounds lighter than it would be with a comparable radial engine.

Upping the Gross

The Moose kit has a gross weight specification of 3500 pounds. The Aerocet 3400A floats weigh 650 pounds and are designed for aircraft up to 3775 pounds. The aerodynamics of the floats carry some of their weight. Considering all this, Orchard chose to set the maximum gross weight at 4000 pounds. At that weight, the finished airplane is slightly underfloated.

The Moose weighs 2795 empty, and with 120 gallons of main fuel, that brings it up above 3600 pounds before anything goes in the cabin. However, fuel can be traded for payload. Fuel for 2 hours of flight can leave more than 700 pounds of payload. Orchard understands that the combination of added gross weight, wingspan, fuel capacity and horsepower requires that the pilot be careful of turbulence, rough water or high indicated airspeeds. He tries to keep the airplane light, but there's no getting around the inherent limitations of amphibious flying, which is costly in terms of weight.

Just a touch of beta will keep the nose of the floats out of the water while idle taxiing.

Around the Lake with Popeye

I, too, am a sailor, and while I have the rating, flying seaplanes is a special treat I seldom get to enjoy. We pulled the Moose out of parking by hand to avoid blowing over the nearby tents. It is so tall and looks so large that pushing it on the grass seemed like a daunting task, but it rolled easily.

It is a long way up to the cockpit—the Moose sits higher than the King Air that donated the engine. The cockpit is roomy and neatly equipped with two Chelton EFISes, and an Electronics International EMS. The electrical switches were a combination of a simple single combined with the necessities of a turbine.

Something I noted to Orchard was one of the few miscues in the build. Piston-powered airplanes always use momentary switches for starters, and that was the case here. But turbine starters need to be turned on and left on until the start sequence is complete. Inadvertently taking a finger off the starter button at the wrong time could lead to a hot start that could melt a very expensive engine. Changing a push button to a rocker switch is an easy fix, however, and it may already be done. The rest of the airplane's systems and instrumentation were simple and intuitive. The EMS was a nice interface with the turbine, and soon we were taxiing to the active.

Some people say amphibs taxi like great big shopping carts. Because the mainwheels are set back and the nose tires caster, the arm on the rudder is short, and the brakes get a workout on a long taxi, but there is no alternative.

I fly my share of high-performance airplanes, and I know what to expect when turning 550 horses loose on an airplane that weighs around 3600 pounds. Even with that expectation, the result was a treat. The airplane accelerates quickly, and soon we were ready to rotate.

Why Floats?

That's one of those questions that whoever would ask it wouldn't understand the answer. Many pilots don't get it. Speed is not the most important attribute of a floatplane. Float flying is about the journey not the destination, and a faster airplane just means the journey will be over sooner.

Payload and getting in and out of small lakes are also more important than speed. Payload means you can take more time, and smaller lakes mean exploring more places.

Float flying is about camping on a beach or sleeping in the back of the airplane when it's beached on a desolate shoreline. It's about having an airplane with room for a fishing pole that's rigged. That means you fly over a lake where the fish are rising, drop in, and have a line in the water before the wake settles on the surface. If the fish bite, you stay until the float locker is full, and if they don't, you pull in the line and move on to the next lake.

Float flying is about building a campfire on the shore and frying up a mess of trout in the Northwest, salmon in Alaska, crappies in the Midwest, and walleyes in Canada. Or you might spear a lobster for a feast on the beach in the Bahamas. It's about lakes with no access by road, on water so flat that you can shave in the reflection or, in the shade of the wing, see the fish swimming along the bottom 15 feet below.

Float flying is about being transported to a place where with the slightest imagination it is easy to believe that no explorer has been there before. It's about being far enough from everywhere that it's impossible to be in a hurry to get anywhere.

But if you asked the question, you probably don't understand.

—D.R.

Everyone in Step, Please

Everything in aviation is a compromise. Floatplanes require more compromises, and amphibious floats add a third dimension to the bargain. There is a place on a float called the step, where the body and the tail of the float meet. It is on this step that the airplane rotates when it comes out of the water. The land plane equivalent of this point would be the axle on a tricycle airplane. It is not possible to locate the tire at the same point as the step, so it must be moved back into the tail. This results in the c.g. of the airplane being farther than optimum from the axle, and it takes a good tug on the elevator to pull the nose up.

On a normal amphib this would result in the initial pitch being too high to sustain. But the power of the PT6A just pulls the airplane wherever it is pointed, and it will climb at ridiculously high angles that preclude all forward visibility. Climb rates in excess of 2000 fpm are possible. Let the nose down to a more reasonable pitch attitude, and the airplane accelerates quickly. The result was predictable—a big grin.

Level off and pull the power back to 60% torque, and the airplane indicates 135 knots on 34 gph—climb to 8000 feet and that should yield 157 knots/180 mph true. But it gets better: This PT6A variant can maintain 60% power to 18,000 feet, where 135 KIAS equals a true airspeed of 180 knots. You just don't think like that around amphibs.

Another thing about floatplanes is the side area on the nose of the floats reduces yaw stability. Couple this with the extended nose from the turbine installation, plus the internal friction in

Putting the gear down, and even more unnerving, up, on the surface of the earth, are cause for a pause to consider your actions. But having that option greatly increases the utility of a seaplane.

Water launching is easy: Pull the stick back, push the power lever forward and hang on. As the nose falls through, the airplane breaks the water and you're gone.

the water-rudder system, and the result is neutral yaw stability. If you push the nose left with the rudder, it stays there. If you push it right, it stays there, too. This may sound problematic, but it isn't. The airplane doesn't sway; it just stays where it's put. Anyone with the slightest amount of rudder awareness would have no problem flying it smoothly.

The ailerons seem a little sloppy at first, but looking at them while in flight, I could see the cause is lost motion in the control system. The ailerons droop with the flaps and reflex when the flaps are up. Ripley said they worked hard to resolve the issue, but could not do it. It is not objectionable, and in a few minutes I had forgotten about it.

We made the short flight up to Lake Agnes at the Fantasy of Flight Museum, which served as the seaplane base for Sun 'n Fun. There was a light chop on the water, and I slowed to 75 knots on final, checked the gear up for water, and put the flaps down. The airplane went on the water as smooth as silk, with just a touch of power. The composite floats absorb vibration and noise, and the ride on the water is smooth. I was apprehensive about pulling the power back abruptly on the step, concerned that flat prop pitch might blank out the tail. My fears were unfounded. The airplane settled easily into the water, and we idle-taxied to the ramp.

The turbine pulled up to the ramp easily, to the *oohs* and *aahs* of the assembled crowd. I tried to back into a parking space in the cow pasture turned amphibious parking ramp. The cows were gone, but evidence of their recent occupation warranted looking before each step. After a short visit, we fired up and taxied down the ramp for a water takeoff. Putting the gear up on an airplane not in flight is unnatural, but that's the drill. Taxiing downwind at idle was just fast enough that the floats were taking water over their bows. The choice was to reduce the prop pitch into beta range, or add power and step taxi. Step taxiing is a better choice, so we powered across the lake and turned into the wind.

A few lakes over, at Jack Brown, they teach the CARS checklist: carb heat, area, rudders, stick. There is no carb heat, but I cleared the area, retracted the water rudders, pulled the stick full aft and added power. The typical water takeoff involves coming out of the hole onto the step, lowering the nose, accelerating and lifting off. The turbine Moose takeoff is simplicity itself: Add power, pull back. The airplane stands on its tail, and as the nose is coming down onto the step, the airplane breaks free of the water and flies, again, at a ridiculously high angle unless you relax the back pressure. Another grin.

Pretty Pictures

The photo work is not usually part of an article like this, but it warrants discussion. A great way to find out how an airplane flies is to snuggle up close

to another. If the airplane has bad handling habits, this will highlight them quickly. By the time we began shooting, I was one with the airplane. It responded to my commands without effort.

The photo platform was a Beech Bonanza A-36 with the rear doors removed; it's owned and flown by well-known aviation photographer Scott Slocum, who graciously agreed to carry his competitor, Richard VanderMeulen, who shot the art that adorns these pages. The elements of a photo shoot are the photo platform, the subject plane, the pilots, the shooter, the background and the light. That's a chain with seven links in it, and it's seldom that all of the elements come together without one or two weak links. We had the chain hooked up, and the magic that you see on these pages is the result.

After several touch-and-goes on the water, in formation with the Bonanza, it was time to return to the pavement. Remember I mentioned how high the airplane sits off the ground? It must have

TURBINE MOOSE

Price (base kit)	$42,262
Estimated completed price	N/A
Estimated build time	11 months
Number flying (at press time)	1
Powerplant	Pratt & Whitney PT6A-20

AIRFRAME

Wingspan	37 ft 6 in
Wing loading	22.2 lb/sq ft
Fuel capacity	160 gal
Maximum gross weight	4000 lb
Empty weight	2795 lb
Useful load	1205 lb
Full-fuel payload	111 lb
Seating capacity	4
Cabin width	46 in
Baggage capacity	250 lb

PERFORMANCE

Cruise speed	180 mph (157 kt) TAS 8000 ft @ 60% of max-continuous, 34 gph
Maximum rate of climb	2000+ fpm
Stall speed (landing configuration)	62 mph (54 kt) IAS
Stall speed (clean)	65 mph (56 kt) IAS
Takeoff distance	"short"
Landing distance	"also short"

Specifications are for this specific airframe, and represent several differences from the normal Murphy Moose specs. Some typically presented figures are not available.

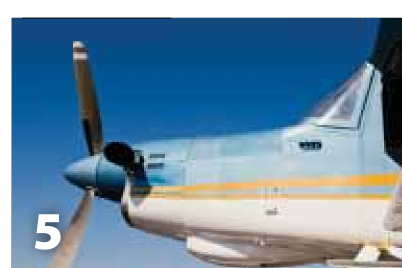
1. The dual Chelton panel would be right at home flying ILSes in a turbine Lancair, but the synthetic vision and terrain information could be just as useful for finding a pathway into and out of mountain lakes in marginal weather.

2. A hefty latch mechanism positively locks the big entry door, and while the window can be opened easily, doing so fills the cabin with hot, smelly turbine exhaust.

3. The trigger on the big power lever allows beta and reverse, a handy feature when maneuvering in tight spaces or in winds on the water.

4. A simple Johnson Bar controls the flaps from 6° up through 40° down, and another simple lever retracts and extends the water rudders.

5. The turbine conversion complements the lines of the airplane and moves the engine forward without looking like an afterthought.



There is an abundance of room for camping or hauling; huge doors provide access.

slipped my mind, because on final for the concrete, just as I was beginning to flare, the tires touched, the trailing link gear absorbed the down force, and the result was a landing much better than I deserved. Call it the end grin.

It's Bigger than the Package

A turbine Moose is not for everyone. Like any airplane that stretches the envelope, it's an airplane that, if not properly respected, could lead to trouble. Its simplicity and pleasant personality conceal those traits, and I didn't go looking in the corners for them.

Rick Orchard is a sailor. He knows the feeling of power in a boat when the mainsail is transformed from a parachute to a wing. Pushing the power lever on the turbine Moose gives him that feeling and makes him grin. He seems to have gotten some kicks from building the turbine Moose as well. He is already started on his next project, an even bigger turbine amphib called the Grizzly, based on a Lockheed AL-60 engine. Maybe he will register it as N24BG, Bigger Grins. ✈

For more information on the Murphy Moose, call 607/792-5855, or visit www.murphyair.com. Contact Aerotek Aviation at 418/802-5278 or visit www.aerotekaviation.ca. Direct links can be found at www.kitplanes.com.

The STAAKEN Z-21A Flitzer

Lynn Williams' modern period piece allows you to indulge your Walter Mitty leanings.

BY BOB GRIMSTEAD

For those of us who, like Snoopy, have entertained the daydream of going head to head with some worthy enemy aviator during wartime, behold the Staaken Flitzer as a way to further facilitate the fantasy. It is a remarkable airplane—the only biplane I know of that will not only fly, but *fly really well* behind the modest power of a VW engine. While the Flitzer is supposed to be a mythical inter-war sportplane, this thing's an eagle in dove's plumage.

Brainchild of British aviation artist and lifelong aeronautical enthusiast Lynn Williams, the Flitzer is a modern design with a distinctly period flavor, masquerading as a 1920s German sport biplane of Great War layout. Williams supplies plans for several sub-types of the basic design. The original Z-1 Flitzer was his bright red prototype, powered by an 1835cc VW. Next came the stronger Z-21, incorporating a longer-span horizontal stabilizer and other small refinements, but still using a 22-inch-wide fuselage. Larger pilots can build the later Z-21A featured in this article, with its enlarged 24-inch cockpit.

The slightly more compact Stummel Flitzer has a shorter fuselage with raked cabane, a larger tank bay and rounded flying surfaces. This model is available in two versions, the Types S and R, optimized for intermediate level aerobatics, using more powerful engines in the 60 to 110 horsepower range. The Stummel Flitzer's structure is strengthened to cope with +6/-3 G loading, and balanced slaved ailerons have been added to its upper wings to improve roll performance.

More than 200 sets of Flitzer plans have been sold. They come as 33 comprehensively illustrated, 3x2-foot sheets, with much text and many perspectives, including exploded views of individual components. All metal fittings are drawn to full size, and the original plans have been updated to reduce fabrication time. Those sub versions are all derivatives, and they come as modifications to the basic plans.

Two Flitzers, No Waiting

I have sampled two of the half-dozen or more flying Flitzers. Englishman Rupert Wasey's award-winning example (the natural wood-colored one in these photos) has an 80-hp AeroVee 2180cc VW conversion with a single magneto and electronic ignition with dual Hall effect coils, each firing two spark plugs. It also has a starter and an alternator charging an onboard battery, and drives a 60x34-inch Alan Newton beech wood propeller. Wasey's plane significantly outperforms an 1800cc VW-powered Flitzer kept in the same hangar. The second Flitzer I flew was Australian design and technology teacher Mark Crawford's. His has an Australian production four-cylinder Jabiru 2200 engine, also developing 80 hp at 3300 rpm, but driving an Australian Helitpera propeller. His blue fuselage mimics that of WW-I Lieutenant Jansen's of Jasta 6.

Flitzers use conventional construction with plank spars and built-up ribs forming the USA 35B wing sections, squared off with laminated wood wingtip bows. All ribs are identical for ease of

The Flitzer's good efficiency makes it suitable for use with modestly powerful, VW-based engines such as the AeroVee seen here.

Photos: Bob and Karen Grimstead

Modern but simple instruments grace this Flitzer's panel.

building, though the lower wing's structure is a little more complex, and the upper wing has a slightly wider chord due to its thicker spar. The interplane struts are complex works of art, using spruce blocks, plywood cheeks and spruce fairings, which make them look like authentic single-piece components.

The short cabane struts are of welded steel tube, and the landing gear is also a steel tube structure: It's a pair of triangular frames supporting two fixed cross-axles. These support a third, floating axle, held in place with tightly wound half-inch elastic bungee. There can be variation in the wheels. The plans call for re-spoked Honda C-90 moped wheels with new hubs and no brakes, but both the examples I flew had fat motorcycle tires and cable-operated heel brakes.

The Flitzer's fuselage is the usual built-up wood box with scarfed ply exterior skins and fabric covering, and beautifully scarfed pressings of 1.0mm and 0.8mm ply for the rear decking and cable fairleads.

Looking Inside

The small instrument panels each hold eight miniature instruments plus a radio. Wasey's is a Micro-Air, which fits

Honda motorcycle wheels with integral drum brakes are an improvement over the period-correct items.

into a standard 2.25-inch instrument hole, while Crawford uses a handheld. Wasey's has a throttle and mixture quadrant on the left sidewall, fuel on/off selector on the right and a sprung carburetor heat knob in the center. Crawford's layout is slightly different, with a single sidewall throttle (the Jabiru's Bing carburetor has no mixture control) next to the choke. Both use cork-and-wire fuel gauges and are otherwise similar.

The Wasey Flitzer's empty weight includes 5 pounds of lead ballast to compensate for its heavy engine; Crawford's is built from denser fir. They both tip the scales at around 540 pounds. Adding 60 pounds of fuel and 180 pounds of the author took our total to 780 pounds—somewhat more than the 750-pound official maximum. The temperature was about 70° F for all of my flights, and generally with a 10-knot breeze slightly across the runway.

The Flitzer is small and short-coupled, with a tall, narrow-track landing gear, so building it with the original fixed tailskid would only be a good idea if all of your flying was to be off grass. Because of this, both owners have fitted theirs with differential foot brakes and a lockable swiveling tailwheel to improve ground handling on hard surfaces.

Looking Outside

Your eyes look straight along the forward fuselage past a small windshield and through a low triangular tunnel of cabane struts. The nose sticks up high ahead and pretty much in the way of a direct forward view, but it is quite narrow, so your weaves need only be 15° to 20° either side. The maingear is nicely sprung, and both airplanes' brakes were exactly right, with no play and enough effect to turn precisely. For a tighter turn, you can ease the stick forward a little and give a blast of power without any tendency to lift the tail and stand the ironmongery on its nose.

When I opened the throttle on Wasey's, that big VW emitted a most un-Volkswagen-like snarl, and the airplane surged forward with steady acceleration. Only a tiny bit of left rudder pressure was needed until I lifted the tail at around 30 mph. Then it gave a wayward dart to the right, easily and immediately caught by a dab of left rudder. At 45 mph in the tail-high attitude, it flew off cleanly with gentle back pressure on the stick. I accelerated to 60 mph in ground effect in the time-honored manner, after which we were soon climbing like an interceptor at an eager 700 fpm. By then you could no longer hear the enthusiastically blattering engine over the roar of slipstream in the wires.

Having a muffler as standard, Crawford's Jabiru engine is much quieter, and it rotates the other way (like a Continental or Lycoming), so right rudder is required; otherwise, its handling was much the same. Its performance was perhaps a little less sprightly, but that was probably a propeller issue rather than an engine one.

More beauty down below. Heel brakes are just inboard of the alloy rudder pedals.

Maximum level speed at full throttle

An alternative to the VW-based powerplants is the Jabiru 2200, shown here just peeking out of an amazing formed-aluminum cowling.

for both airplanes was about 95 mph IAS, but setting 3000 rpm on the VW gave a comfortable 85-mph cruise, burning perhaps 4 gph for an effective safe endurance of 2 hours. Wasey usually cruises his at 75 mph at about 2750 rpm. Neither airplane is about raw speed.

Being a biplane, visibility in flight is inevitably less than brilliant forward past all those wings and wires, but it is more than adequate, especially behind the trailing edges. Both windshields were a little small for me; I could feel the wind biting between my goggles and the helmet's rim. Nevertheless, it was great to wheel and turn over the countryside, framing golden villages and green fields between those silver wings.

Swing It Around, Then

Turns each way need just a little squeeze of rudder to coordinate; overdo it with a bigger, Tiger Moth-sized push, and the nose will slew across the sky. As expected, Flitzers have low aileron forces, with instant response and a high roll rate. The ailerons are very powerful and the elevator is light, but with plenty of feel. Indeed, all of the controls are light and, yes, nicely harmonized, something writers often claim without it really being true. Believe me, this airplane has classically harmonized controls, with light ailerons, slightly heavier elevators, and a rudder that is just slightly heavier or firmer in feel—perfect!

I made tight turns left and right with the cabane struts parallel to and just above the horizon. This gave a neat and easily judged 60° or so of bank, and I was satisfyingly able to hit my own slipstream after just two rotations. A properly coordinated wing-waggle was a bit harder, because at first I used too much rudder. A squeeze is all you need.

A traditional tail, beautifully sculpted; don't look for the elevator trim.

Nevertheless, the slow handling is fine. Throttled back, speed reduces more gradually than the low inertia and apparent high drag led me to expect. However hard you raise the nose, a Flitzer won't really stall, but just mushes downward at 41 to 45 mph (depending on airplane, weight and configuration). With no elevator trim, 8 to 10 pounds of stick back

pressure are needed to achieve a stall.

Even with some power on, these airplanes just nod their noses, with no warning buffet, but no wing drop either. But they do sink power-off. Doing just a couple of stalls lost me a full 500 feet!

Williams told me that the Z-21 is significantly stronger than the prototype Z-1, which was designed to the old British Semi-Aerobatic category of +3.8 G with a reserve and +4.4 G ultimate. All reserve factors on the Z-21 were subsequently increased for those components with less than a 1.5 reserve. This makes Z-21 Flitzers fully aerobatic, with a maneuvering speed of 100 mph and a 120-mph Vne. Nevertheless, Williams recommends against flying snap maneuvers, sustained inverted flight or outside maneuvers.

Tilt-a-World

First I tried a few wingovers, each way, in both airplanes. These were easy and tremendous fun, so I went further, flying gentle aerobatics from 3000 to 2000 feet with a maximum of 2.5 G. Wasey had warned me that his could flick if you pulled too hard over the top of a loop, which surprised me, considering the Flitzer's light weight and low wing loading, but I didn't encounter this problem with either airplane.

You need some rudder each way in the loop but not much. I started my first at 110 mph and saw 40 on the dial over the top. All my loops probably weren't properly circular, but they were tight, and it was satisfying to look up over the center section to admire the inverted world above while floating across the top.

Barrel rolling to the left at 100 mph was a bit difficult because of interference between the stick, my knee and the throttle. It was easier rolling to the right, but either way you do have to raise the nose *very* high before applying aileron or else it falls a long way during the maneuver, even if you roll with full aileron. Wasey said he got a face full of fuel when he tried a slow roll. Neither airplane's fuel cap had been modified for aerobatics, so I decided not to bother.

Hammerheads took increasing rudder on the way up (left with the VW, right with the Jabiru). Holding each airplane in the vertical for just a moment (as anticipated, they slow quickly), I hit the appropriate rudder at 40 mph and round they both went, pirouetting right on the spot, sweet as a chocolate-coated nut, and with little need for either forward elevator or opposite aileron. Throttling back halfway around kept the radius tight and gave me plenty of time to accelerate in the downward vertical before pulling out.

Back in the pattern, I flew downwind with 2500 rpm and 65 mph, and then throttled back to 2000 rpm for the approach at 60. Wasey said not to fully close the throttle because the plane sinks rather rapidly in this configuration, though when I was more used to the type, I did try several glide approaches. Some stick back pressure is needed at this speed, but there is still plenty of control authority for countering gusts.

A curving approach is best for decent forward visibility, and to keep the threshold in sight. With the nose well down to hold 70 mph, I found I actually got the best view of the runway by stretching my neck to look over the top wing. There is plenty of elevator effec-

STAAKEN FLITZER

Price (plans)	$300
Estimated completed price	$12,000 - $15,000
Estimated build time	800 hours
Number flying (at press time)	5
Powerplant	VW-based, 1800cc
Propeller	two-blade fixed-pitch
Powerplant options	AeroVee 2180cc, Jabiru 2200

AIRFRAME

Wingspan	18 ft
Wing loading	7.73 lb/sq. ft
Fuel capacity	10.6 gal
Maximum gross weight	750 lb
Typical empty weight	540 lb
Typical useful load	210 lb
Full-fuel payload	148 lb
Seating capacity	1
Cabin width	24 in

PERFORMANCE

Cruise speed	86 mph (75 kt) TAS 3000 ft @ 75% of max-continuous, 4.3 gph
Maximum rate of climb	720 fpm
Stall speed	42 mph (37 kt) IAS
Takeoff distance	900 ft
Landing distance	400 ft

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

tiveness, with or without power, and on one occasion when the Jabiru stopped on final, I found there was still enough elevator control for a proper flare. Despite a fairly prolonged hold-off, these little airplanes don't float far, thanks to that vast amount of drag, especially with the nose raised and the undersurfaces of all four wings presented to the airflow.

Now You Can Land It

You have to rotate the nose through a big angle to get it up to the correct three-point attitude, and this takes time. However, if you are not patient, and your stick is not fully against the backstop by the time the wheels brush the turf, the airplane will bounce on its stiff maingear legs. Trying to correct this by pumping the stick back and forth merely causes pilot-induced oscillations and divergent bounces. The only solution is to open the throttle and go around.

Crawford's Jabiru Flitzer was better in this regard; its slightly softer bungees have a little more give and generally allowed a softer, bounce-free landing despite my repeated inability to get the stick all the way back to its rear stop.

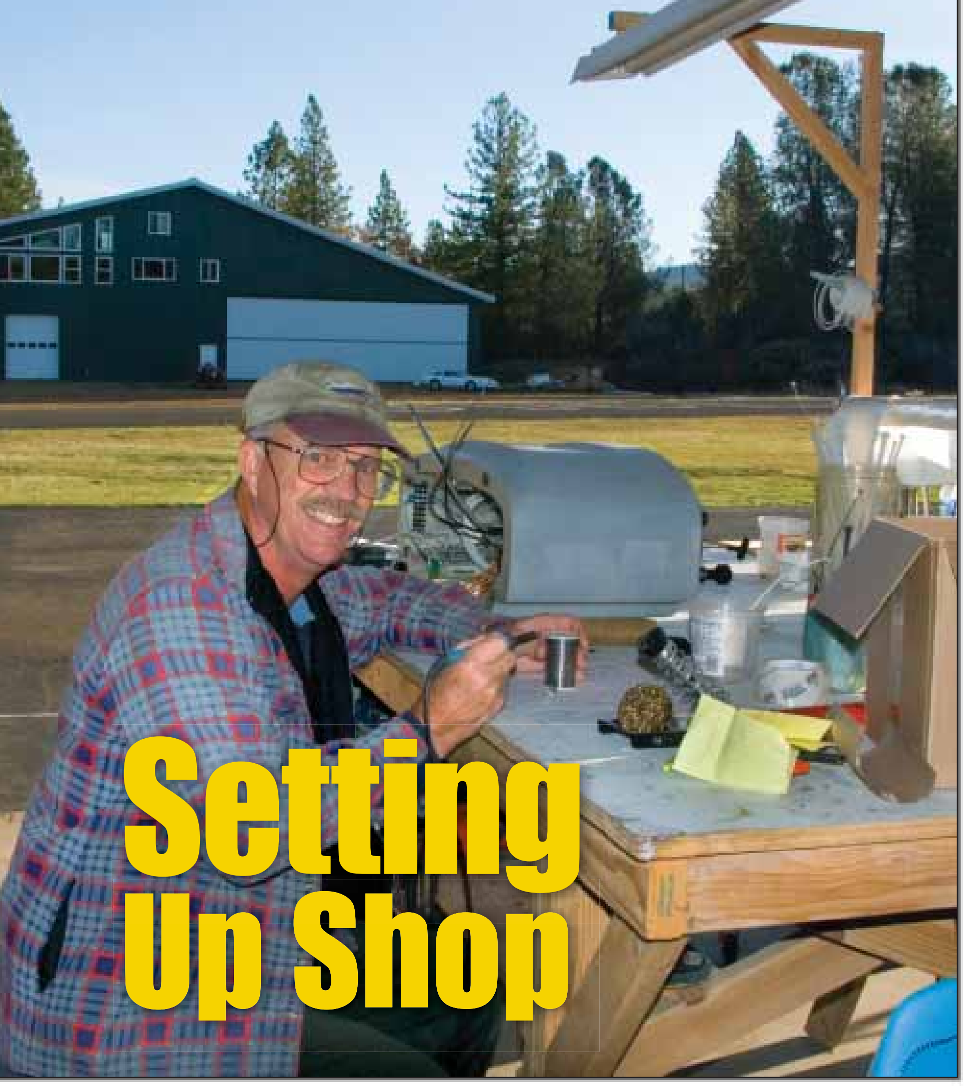
When you do get the flare right, and everything comes together nicely, it can be truly rewarding. For a proper three-pointer, you hold the stick right back into your gut at touchdown, and then ride out the little bounces and waddles as you gradually lose momentum, dancing your feet lightly on those rudder pedals (and, occasionally, the brakes) to keep straight.

Nearly every time both airplanes slowed, and despite their engines rotating in opposite directions, they both showed a distinct attraction toward the trees along the right runway margin. Sometimes an early rudder input would stop this before it got started, but on other occasions a good jab of left brake was needed as well. I did not fly either off a hard-surface runway, but I suspect that would be more challenging.

Nevertheless, and partly because of their ground manners, Flitzers are the kind of airplane you would never tire of—endlessly challenging to fly accurately, but immensely satisfying when you get things just right. Nimble, maneuverable and sprightly, their handling is perfect for the connoisseur. Above all, they're just so much fun! ✢

For more information, contact Lynn Williams by emailing flitzer@btopenworld.com. For the North American dealer and parts kits information, call 780/417-2008, or viist www.flitzer-aero.com or www.flitzerbiplane.com.

Find info about Rupert Wasey at http://www.av8rblake.com/flitzer/Rupert-Wasey and Mark Crawford at http://members.iinet.net.au/~hawk1.



Setting Up Shop

Think you don't have enough room?

Here's how to make the best of the space you have!

BY BOB FRITZ

"I can't build a plane! I don't have a workshop, and even if I had the tools I don't have the space!" Or so goes the lament as you walk away from the airport, head low and feet shuffling in abject surrender (include sound of can being kicked).

First, remember that "defeat" is where you put your shoes, and "denial" is just a river in Egypt. Proof? How about several builders who've built RVs in their apartments? While that example is a bit extreme, it does illustrate what can be done when tenacity and grit combine with ingenuity, perseverance and tolerant neighbors.

But where to start? It's sort of like eating an elephant...you do it one bite at a time. After all, many successful builders will admit that they might not have finished the project had they really kept the end-goal in sight every day. Build an airplane? It's too daunting a task. Better that you concentrate on today's task, e.g. "I'm building an aileron." It's a much smaller bite.

Similarly, building a shop is a bite-at-a-time project. Unlike eating an elephant, however, a shop has no end goal. It's more like going fishing. "When will you be done?" is never the question. Attitude is everything. So, with a recalibrated sense of the possible, let's take a look at *where* to begin, not *whether* to.

Where to Put It All

By where, I'm not talking about the geography. No, it's easier than that. Just decide on your medium such as aluminum, composites or fabric, buy the basic tools, a beginner's kit such as the tail, and diddle around with it instead of watching television. You don't have to lay out a miniature version of Burt Rutan's Scaled Composites.

But the first project in any really good shop should be a really *organized* shop. I don't mean just putting tools away, though that's important, but rather having an efficiently arranged shop. Without that, you're just emulating Sisyphus, that poor schmo who the Greek gods condemned to rolling a boulder to the top of a mountain only to find it back at the bottom each morning.

While an apartment is a tough way to start building a project, a one-car garage is eminently workable. In fact, it can be easier than a two-car garage if you have to share it with a car. With a one-car garage you get, assuming the car is outside, all the walls. In a two-car garage with one car inside, you'll have one wall fairly inaccessible.

No matter how many walls you have, there's still the ceiling. A powered rafter table such as the RacorPro HeavyLift is

The garage bench was built to take the compressor below it. Note that the legs go into wall studs, leaving the floor clear for sweeping and pulling out the compressor if needed. The author is 6 foot 2, so this bench is about elbow height for him.

a great way to store what you don't need right now, but will need tomorrow or intermittently. Judicious shopping will allow you to acquire one for less than $130. Just use some caution when you load it down; you don't want to have the ceiling on the floor.

Finished components such as a wing can go to one of those rental storage places where, for a reasonable fee, you can leave what you don't need for a while. Just remember to throw a plastic sheet over it; even if the roof doesn't leak, you don't need a layer of dust that encourages corrosion.

Pegboard seems a tempting solution, but it's not a favorite of mine. Those hooks are always coming off the board, even when they've been captured by the little plastic clamps that are supposed to prevent it. Most tools should be stored in a roll-around toolbox. Longer tools, such as those long bar clamps, are OK on the pegboard, but nothing heavier than an electronic level ought to be entrusted to those fiberboard holes. You will need shelves, of course, so the type with their rails screwed to the wall studs is best.

If you decide to go for pegboard, remember that it has to be spaced out from the wall. He-who-shall-not-be-named once nailed it to drywall and then suffered the slings and arrows of innumerable base canards. "Yep, there's a nut loose on both ends of every one of your wrenches" and "Interesting wall art you got there!" Adding insult to injury, I had been quite proud of the accuracy with which the nails were centered on the studs. The only solution was to get another sheet of larger pegboard and go over the first—after the spacing strips were installed.

Bob's shop is set up with welding in one corner, machining mid-wall, supplies at one end and this little bench for holding a vise and measuring. Tools that are too big for the toolbox go on the wall; pegboard works here if the tools are light and the hooks are secured.

As for roll-around toolboxes, you can go for one with a workbench built on top, but they cost $3500 and up! And you're likely working in a small area, so heavy-duty, large-diameter wheels for easy rolling around is not critical. A $200 box from Sears has served me well for the last 30 years. Instead, build a workbench that fits tightly against one side of the garage. For instance, if you have a side door into the garage, place the toolbox next to it and then build the bench to fit the remaining space.

The black plastic cross strap does a fair job of holding the hook in place, but anything heavier than a couple of wrenches risks pulling it out. Oddly enough, if you do reposition the hook, pulling out the strap rounds out the back edge of the hole, making that position weaker if you go back to it.

Photos: Bob Fritz

The Workbench

"Where can I get a good set of plans for a workbench?" My answer to that is, "Your own imagination." Those generic plansbuilt benches are usually too low, too short in the left-right dimension and too deep to allow a car in the garage when the project is finished.

Let's start by assuming you're working in your garage. This is a stand-up bench, and it's your bench, so put its height where it's comfortable for you. If you have a shorter toolbox, you'll find that a bench that just goes over the top of the box is perfect. The best way to start is to roll the toolbox into place against the wall, then scribe a line on the wall about an inch above it. Now screw a couple of blocks against the wall with their upper edges just touching the line. You'll remove these later, so one screw in each is fine.

Next, measure the distance from the wall to the edge of the garage door; that's the depth of the bench. Finally, park the car and make a mark on the wall in line with the leading edge of the driver's door; that's the maximum length of the bench. Use the leading edge as your limiter, because you'll need room to swing the door plus a little clearance.

You now have the length and depth of the workbench, so cut ¾-inch plywood to that size. If you can't get a 4x8-foot sheet into your Mini Cooper, places like Home Depot will cut it to size. The 2x4s on edge will be the framework underneath, so cut them to go the full length of the plywood and a couple of inches shorter than the width of the plywood; this is to give you a cantilevered edge along the front of the finished bench. You'll need that lip for clamping things along the front, but you won't need it on the back or ends, so extend the frame out all the way. Depending on the size of the plywood deck, you might add a couple of cross braces between the front and back parts of the frame. Line those up with the wall studs.

You're supporting the back of the bench by screwing it to the wall, so just put the bench on a 1-inch spacer on top of the toolbox, position the back edge on those blocks you put on the wall, and then screw the bench frame to one of the wall studs.

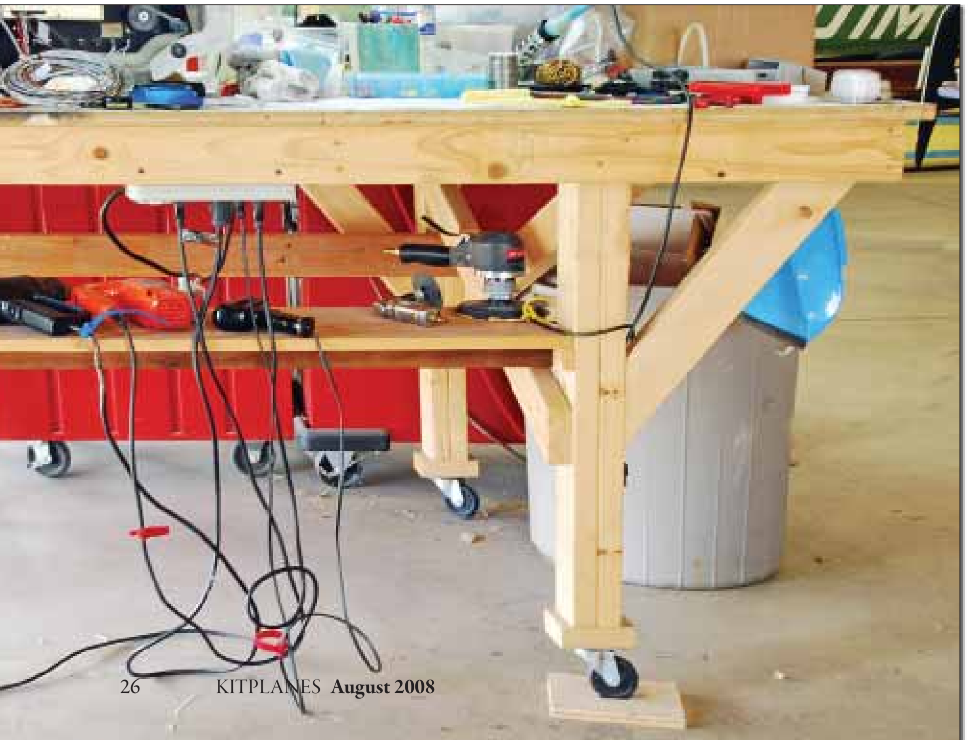
Now, check the bench for level, adjust it with shims between the bench frame and the toolbox, and add a couple of screws to the back of the frame on the wall. You've still got it on the toolbox, so run 2x4s diagonally down from the front of the frame down to the wall studs, stopping above the floor to make sweeping easy.

If you use vertical legs, you have to support the lower ends with a horizontal 2x4. That's a good start for a shelf, but it prevents putting anything under the bench that won't fit on that shelf, such as a compressor.

Buy a box of deck-screws to assemble it all. One brand includes a bright blue Phillips bit that's a perfect fit and really makes it easy, especially if you include a

This triangle is screwed into the side of the bench against the wall. That smudged dot is the contact point for the clamp.

And this clamp is screwed to the wall. The block is built at the angle that drives the bench against the wall and against the solid stop on the wall down at the other end of the bench. The result is that when this one lever is tripped, the bench rolls out to anywhere one would want it.



The author has a hangar adjacent to his shop, so his main bench was built on wheels. Divots were cut into the wood blocks you see under the front wheel(s). Lockable casters are neat, but this works, too. Note the long shelf underneath and the power cords coming from the below-bench power strip. That strip terminates at the back of the bench and means one extension cord works for all. The bench top is made of ¾-inch plywood with a glued-on topping of Melamine. It hides the screws and looks great, but it's not recommended; acetone quickly lifts the pretty white layer.

This commercial-grade air dryer/filter is critical to keeping the air dry and clean. Just remember that it needs servicing via that water-dump valve on the bottom. It's also a genuine pressure regulator. That's important when you don't want to over-drive rivets or blow expensive paint all over the shop.

neat little $2 tool that captures the bit and the screw in an extendable sleeve.

A nice aid would be to add a power strip under the bench. This way you don't have the cords draped over the workspace. If you can also add a shelf under the bench, you'll have a place to store the corded tools. Don't forget to size the shelf so that the compressor can be removed without knocking a hole in the garage wall. (No, I did not make that mistake.)

If you have room, put the bench on wheels. A couple of clamps will allow you stabilize it against the wall. This would work for a small shop, and might be even more useful in a limited space situation.

Of course, you can't put the compressor under this configuration if the front legs are vertical, but that's one of the trade-offs. When I was in a one-car, and later two-car garage, I had the compressor under the bench. Now that I have a hangar, there's room for a big, vertical compressor, so I use the roll-around configuration.

The Compressor

You'll probably want to buy a compressor right now to size the bench. Don't.

Assembling the bench is made a lot easier with a cordless drill driving a screw holder (two sizes shown) and a tip specifically for those deck screws. Deck Mate includes a new bit in every box.

Buy the air tools you'll need. Those cheap-o kits are, surprise, perfectly fine for the homebuilder. Just remember to put three drops of oil directly into the air inlet right before using them, and they'll give good service.

Once those tools are in the box, check for the one that uses the most air. The pressure is not really the issue here; it's the cubic feet per minute (CFM) rating that sizes the compressor. An insufficient compressor makes about as much sense as a cow in a track suit.

If you choose to put the compressor under the bench, it won't be the vertical type. That doesn't mean it has to be low capacity or noise cursed. Reliability and noise can be kept under control by buying a piston-type compressor. It's no small issue if the neighbors start complaining that you're more annoying than those mega-watt automobile systems, so have your spouse go with you for a racket check.

If you're stuck with a really noisy beast, the compressor, that is, you can construct a plywood box around it and line it with foam. If it has anywhere near the CFM capacity you want, it won't overheat in the low-cycle use you'll give it. This worked fine for the one-car condo garage I used to have.

Remember that any holes will leak noise in copious amounts. To appreciate this, consider that a 1-cubic-foot box with perfect insulation allows 90% of the noise to escape if the box has only a 1-square-inch hole. If you don't believe it, consider the noise reduction that occurs when you close the laundry-room door that last eighth of an inch.

This sort of shelf is strong enough for the entire collection of FAA manuals. Resist the temptation to use the 15-inch length, though. You'll lose stuff to the back of the shelf if it's above eye level.

This shelf bracket is good for storing a roll of paper towels and not much more. You wouldn't expect spindly wire held in place by paper-composite fiberboard to keep your airplane up, so don't expect it to support your tools.

The coiled hose looks trick and would work well if attached to an overhead drop line. But this configuration gets tangled on bench corners, gear legs, doors…everything. Use a non-plastic 6-foot length of hose for better results.

You're also probably tempted to install an in-line oiler. Again, don't. You'll coat the air lines with oil and wind up spraying oil on the working surfaces. You should, however, install an air dryer in the line. You can add a couple of drops of oil into the inlet of the tool to make up for the loss of the oiler, but a couple of drops of water through the tool can destroy it in short order.

One last item here is the hose. First, skip that coiled hose; it just gets hooked on everything. Self-retracting hoses are nice, but they can also be a nuisance, as they're usually too short, too small or too expensive. The cheaper plastic hose is usually bright orange and costs about $10. But it's stiff, especially when it's cold. Buy only $^3/_8$-inch inner diameter rubber hose for about $35, and you'll be a lot happier. If you want to set this up right, visit your local paint supplier for advice. He probably has a schematic of an air system for a paint shop that will show some great ideas on pipe sizing and water traps.

Shelf Life

Shelves are critical, and you can't have too many...well, yes, you can. Leave a space on the wall for drawings if they're the big C and D size, or build an angled shelf to hold the binder open. That way it's not using your precious bench space. Here's one place where pegboard and long wire shelf supports are useful; just bend the supports down to a reading angle, and then put a hook in the end to keep the binder in place.

The shelves that you do build should be strong enough to support the weight of several gallons of paint. The upper shelf should be 8 inches deep, and the lower 12 inches. Any deeper, and you'll lose your materials to the back of the shelf upper. Those vertical metal brackets with adjustable shelves work well. Just make sure you screw them into the studs and not into drywall. A $20 stud-

The aluminum cutting end of this bench grinder looks a bit better. But this is why you don't want to position the bench grinder near anything else. With that in mind, you don't need a deep bench to support it. This bench is only about 15 inches to the wall and well away from precision tools. It could be even less than that and still be fine.

finder is perfect for finding the studs with far greater accuracy than knuckles rapping on drywall.

Similarly, you don't need a deep bench for the smaller bench-mounted tools such as grinders and belt sanders. You don't want anything stored in the vicinity, because it will be covered in grinding wheel dirt, so be sure to give them a separate home.

On those narrow benches you should mount a bench grinder with an aluminum-cutting wheel. You'll need this no matter what medium your chosen project is built of, as they all require plenty of aluminum. Right now you're probably saying, "He's got plenty of room for all those benches!" But in fact I set up most of these small benches around the one-car condo garage where I built 90% of my RV-6.

You'll also want a 1-inch belt sander with a supply of extra belts. A buddy of mine refers to his as his "belted milling machine." But it's often mated to a rarely used 5-inch disk sander, so don't take up the space with one if you have a choice.

What you should find wall space for is your collection of metal files. Don't put them in a drawer! Take a close look at the teeth on a new file and compare it to one that's been tossed into the drawer with other files. The latter will have shiny spots on the surface, which are dulled teeth caused by banging a hard edge against a hard edge.

You won't be surprised to learn that I still do not recommend pegboard for this application. No, take a look at a similar problem in the kitchen: You don't toss those big-bucks Henckel knives in with the Sabatier stuff do you? Not if want them to stay sharp, you don't. Wood blocks are fine for knives if you have the counter space, but a magnetic strip works better. It works for files, too, as long as the magnet is good. Cheap strips are not likely to have the necessary holding power, so take your largest file into the kitchen supply store and try it out.

Last on the list should be three catalogs: Aircraft Spruce, Enco and Harbor Freight. And one more thing. If you're like me, you can hang up a sign that says:

Pegboard, yes, but note that the magnetic strip is screwed to the wall. Cordless-tool batteries are on the shelf above, so if the load is light, it's OK but not ideal.

"If it can't be fixed with a hammer, it's an electrical problem." ✈

We'd like to hear about your solutions to the space issue. Do you have a good tool or technique that makes you smile when you think of it? Send a photo and a description to editorial@kitplanes.com. The smile is fine, too.

Build Your Skills

FABRIC

Choosing the "right stuff" for your project.

BY RON ALEXANDER

Selecting the right type and weight of fabric to cover your airplane project can be confusing. Advice on the correct fabric is plentiful, varied and sometimes inaccurate. Years ago, aviation pioneers used a wide variety of fabrics on their aircraft and finally chose different types of linen and cotton. Grade A cotton, as it is referenced, became the standard fabric for use on most aircraft until the 1950s. However, cotton material was and remains susceptible to deterioration from sunlight and mildew. Polyester fabric was later developed and has become the fabric of choice for aircraft covering. Different styles and weights of polyester are available, and determining the correct weight is an important consideration. As you will see, the aircraft's mission, engine size, aircraft speed and other factors influence the fabric weight you need to use.

A Bit More History

The early pioneers in aviation realized that a better alternative to muslin and cotton fabric needed to be developed. Cotton fabric must be coated with nitrate dope—a flammable chemical. Nylon was tested only to find that it stretches too easily, and after being shrunk returns to its original state.

Polyester material was developed during the 1940s in England. DuPont obtained the rights to manufacture this product in the United States under the trade name Dacron. DuPont published information on shrinking this material by applying heat, and Colonel Daniel Cooper began testing polyester fabric for aircraft applications. In 1958, Cooper termed his new material Ceconite and began selling it to cover aircraft. By this time butyrate dope had been developed and was being used as a coating.

During the early 1960s, Ray Stits developed a fabric covering system using polyester fabric, which used chemicals other than nitrate and butyrate dope. He wanted a system that would not support combustion and that would not continue to shrink fabric over time. (Nitrate and butyrate dopes will continue to shrink both cotton and polyester fabrics through the years. This shrinkage is not critical if the fabric is properly applied.) The Stits Poly-Fiber covering system was introduced in 1965 and rapidly found widespread use.

A light weight polyester is 1.7 ounces per square yard of material and is good for very light and slow aircraft.

Heavier cloth, at 3.4 oz./sq. yd., is suitable for faster aircraft. It's marked for reference, but the feel is distinctive.

Fabric Type	Weight	Thread Count	Breaking Strength
Light	1.7 oz./sq. yd.	92 x 76/in.	67 lb./in.
Medium	2.7 oz./sq. yd.	68 x 62/in.	102 lb./in.
Heavy	3.4 oz./sq. yd.	68 x 56/in.	125 lb./in

Chart 1.

Fabric Options

You have limited choices regarding fabric. Polyester is the main type available today, as Grade A cotton has all but faded away. To my knowledge, there is no Grade A fabric available today that meets FAA requirements. If you find Grade A fabric, you must ensure it meets the proper specifications listed in the Technical Service Order C-15d.

All types of polyester are basically the same regardless of their name. Both Poly-Fiber and Ceconite contract with a mill to have their fabrics loomed to the same specifications. Cooper Superflite is similar. Polyester fabric for aircraft will heat shrink approximately 10 to 12%, which allows us to apply the fabric loosely to the aircraft structure and then shrink it using a properly calibrated household iron. This provides the aerodynamic tension needed for flight.

Fabrics are also identified by their weight, which is measured in ounces per square yard. Light weight fabric weighs 1.7 ounces per square yard, medium 2.7 ounces, and heavy 3.4 ounces. The thread count of each fabric varies among types with the light weight fabric having a higher thread count than heavy weight; the light weight fabric will appear smoother. Strength of the fabric also varies with weight. Light weight fabric has a lower breaking strength than heavier weights (see Chart 1).

Tapes are system-specific. Poly-Fiber tapes should not be used on Ceconite fabrics and vice versa.

Fabrics are certified by the FAA for use on production aircraft through Technical Service Orders (TSO), which apply to all aircraft fabrics including Grade A cotton. Fabrics are certified for use on production airplanes and should have a Parts Manufacturing Authorization (PMA) stamp, which specifies weight and type. Certified fabric has been inspected for flaws prior to being shipped for use on aircraft; non-certified fabric has not. If you are covering a production airplane, you *must* use only certified fabric. Ultralights and Experimental aircraft may use non-certified, but it is not recommended. Covering systems must possess a Supplemental Type Certificate (STC) to be used as replacement fabric covering systems on production aircraft. The inspected and certified fabric mentioned is part of this STC process. If you do not see PMA stamps on the fabric you purchase, do not use it on a production airplane.

The PMA stamp appears at 3-foot intervals on certified fabrics. The ink is a special type that will not bleed through the final coats of paint on your airplane. A point to remember: Do not use ink pens to mark on fabric while re-covering your aircraft; use only pencils. Most inks (except the one used for the stamp) will bleed through the final color coats.

Certified fabrics are regularly tested to comply with FAA requirements. The U.S. Testing Company, an independent testing entity, conducts the tests, which include bursting strength, tension and tear strength. The results are published.

Down to the Requirements

With all of this in mind, what factors influence selection of fabric for your covering project? One of the major problems associated with fabric covering has to do with the fabric flexing when the airplane is flying. Flexing problems are most prevalent in the prop-wash area of an airplane. Excessive flexing cracks the coatings that have been applied to the fabric, which results in rapid deterioration of the entire covering, and causes premature repairs or even a complete re-covering of the airplane. Light weight fabrics are more prone to this problem than heavier fabrics, which damp the flexing motion simply due to their heft. A contributing problem results from large spaces between structural members such as wingribs, which cause more flexing and bending of the fabric. Add

Photos: Marc Cook

to this a high horsepower engine and a propeller that is beating the area, and the problem becomes even more acute.

Another problem is on gear legs, where the engine exhaust may be blasting directly on the area. Again, light weight fabrics are more susceptible to damage here. The underside of a fuselage is another area where problems can occur due to rocks and other debris being thrown against the surface.

So let's get to the point. What fabric should you use? First of all, we have determined that you should use polyester fabric. Even if you can find Grade A cotton, it may not meet FAA requirements, and it is a more difficult system to apply.

Tapes come in varying widths and weights for certain applications on the aircraft.

At Poly-Fiber, large rolls of fabric are brought to the warehouse. Subsequently the fabric is rolled out, inspected and placed in measured rolls for sale.

Chart 2.

Airplane Type	Fabric Type
Ultralights, very light aircraft, gliders, aircraft less than 65 hp, most LSA.	Light Weight
All normal service aircraft—kit aircraft, antiques, classics, newer production aircraft—in short, most airplanes using normal airports.	Medium Weight
Aerobatic aircraft, ag aircraft, warbirds, all larger aircraft.	Heavy Weight

Weighty Matters

What about proper weights and styles? On light aircraft with a wing loading of less than 9 pounds per square foot with never-exceed speeds of less than 160 mph, you can use light weight (1.7 ounces/square yard) fabric. The aircraft found in this category are ultralights, very light aircraft, gliders, most Light Sport Aircraft and kit aircraft with engines of less than 65 horsepower. It should be noted that both Poly-Fiber and Ceconite light weight fabric is uncertified, which means it can only be used for Experimental aircraft, not for production airplanes—with one exception. If you were covering a plywood surface on a production airplane, you would be able to legally use the light weight uncertified fabric.

For aircraft not in the above category, medium weight fabric (2.7 ounces/square yard) is considered the standard. In other words, medium weight fabric may be used for all normal service aircraft including antiques, classics, kit aircraft and all contemporary designs that anticipate normal airport operations. Heavy weight (3.4 ounces/square yard) fabric is recommended for more severe operating conditions and for high-wing-loading aircraft. The polyester filaments in heavy fabric are larger and the strength is greater, resulting in excellent resistance to damage and to tearing. Heavy weight should be used where a tough, durable, high-tension fabric is needed, including aerobatic planes, ag planes, warbirds and larger aircraft. (Chart 2 shows proper selection.)

Poly-Fiber fabrics are identified as light uncertified (1.7 ounce), medium (2.7 ounce), and heavy duty (3.4 ounce). Ceconite fabrics have uncertified light (1.7 ounce), Ceconite 102 (2.6 ounce) and Ceconite 101 (3.4 ounce). All of the fabrics are 70 inches wide with the exception of the light weight fabric, which is 60 inches wide. Fabrics are sold by the running yard, so that you can calculate the amount needed for your project. Both the Poly-Fiber covering manual and the Ceconite manual contain yardage estimates for most popular homebuilt aircraft.

A simple ink roller marks the fabric as inspected and approved.

Let's Go to the Tape

Any weight of tape may be used with any style of fabric. Most experienced builders use light weight tapes on all weights of fabric. A light weight tape is simply light weight fabric that has been cut into different widths of tape, typically 1, 2, 3, 4 and 6 inches wide. Medium weight tapes are cut from medium weight fabric. Do *not* use cotton tapes on polyester fabric. Do *not* use Ceconite tapes on Poly-Fiber fabric or vice versa. Doing so will void the STC of each system. Ceconite and Poly-Fiber tapes will work on the other fabric, but it is not legal to use them on production aircraft. We will discuss more about fabric tapes later in the series.

All types of fabric will deteriorate in direct sunlight unless properly protected. There is no so-called "lifetime" fabric. Polyester fabric is not as susceptible to this problem as cotton; however, if bare polyester fabric is left in direct sunlight for 12 months it will lose over 85% of its strength. Cotton fabric exposed to the same sunlight for the same period will deteriorate almost completely. Polyester fabric is protected from UV rays with chemical coatings containing aluminum pigment. Application of the recommended number of aluminum coats will provide adequate protection for years. (We will discuss how to do this later.) A properly applied covering system should have a 15-year life even if the plane is left outside. The same system on a hangared airplane should result in more than 20 years of service.

After selecting the proper weight of fabric for your covering project, how you attach it to the structure is equally important, especially achieving the correct tension. Next time we'll discuss how to apply the fabric and the proper way to shrink it for final tautness. ✈

This machine is used to measure out full bolts of fabric. Bright lights underneath help the inspection process.

ALL ABOUT AVIONICS

Steam Gauge Special

In a world awash in electronic instruments, there's still a place for the old school.

BY STEIN BRUCH

If it seems like we've been going on and on about electronic flight instrument systems (known also by the unwieldy EFIS acronym), you're right. We have. But it's a reaction to the marketplace for new installations.

I also recognize that there's a place for traditional instrument packages—round dials, mechanical gyros, discrete devices—and we're going to talk this month about the benefits (and weaknesses) of this technology.

Here, we can benefit from my own experience. I fly what today would be considered an older-generation RV-6. I often get comments (I won't say nasty) from people after they see the instrument panel. You see, it's filled with basic old-generation steam gauges, complete with a vacuum-powered artificial horizon (AI) and a directional gyro (DG).

Ask Me Why

People wonder why my plane would have such old-school instruments when my shop is busy building the most high-end EFIS panels available. Well, here's the truth, on many levels. First, that was the only stuff available when we built the plane. Second, I just don't need it. Third, I simply couldn't afford the high-end widgets even if I wanted them. (And you thought avionics shops printed money...)

Sure, it would be nice to have a big glass panel, huge moving map with traffic, satellite weather and a built-in music player, but my basic round gauges, simple radio stack and handheld GPS get me everywhere I need to go. I'm fully legal for IFR flight, have onboard weather (thanks to my nifty little Garmin), and my simple autopilot makes everything easy. I still have a rather old looking VOR/GS/ILS indicator—hey, it works.

My airplane proves there is still a

This is an inexpensive, if slightly dated, way to approach steam gauges. The TruTrak turn coordinator/autopilot is among the newer pieces here.

This is an utterly traditional "six-pack" main panel with an inexpensive (I-K Technologies) engine-monitor package. Notice that the gyros are vacuum driven.

place for good old round gauges. Affectionately, we refer to them as steam gauges, in part due to their similarity to the displays in old trains and such. Many people are still building truly affordable planes, and often they are completing the entire plane for less than a new Lycoming engine costs! Some are building day/VFR fun-flying machines and have recognized that the latest gizmos only add weight to the airplane and cost to the building process. Learn from them. Those of you building such an airplane will have little use for expensive high-end electric instruments.

There are pros and cons to going with glass over steam gauges. Let's take steam gauges system by system, and I'll help you avoid the mistakes that I and others have made in this arena. You conservative EFIS buyers take note of these recommendations for buying backup instruments.

The Pitot-Static Instruments

Primary flight instruments would be airspeed and altitude, so you need an airspeed indicator and an altimeter. Duh. Both instruments in their simplest forms are purely mechanical devices that basically display their associated parameters. Airspeed indicators measure the difference between the pitot pressure and static pressure of the aircraft. It's important to realize that the airspeed displayed is a simple indication of the aircraft's relative airspeed through the air around it. This does not account for variations in temperature and pressure, which would give you true airspeed.

Most airspeed indicators are available in a variety of sizes and configurations, including a display in knots, mph or both, as well as specific range markings for your aircraft. They can often be purchased with optional internal lighting at an additional cost. As a whole, most airspeed indicators are fairly trouble-free instruments that will last many years. Costs range from $150 to $1000 depending on whether the unit is certified or non-certified. My experience is that the better non-certified instruments will work fine, and the added cost of the certified device is not always warranted.

An altimeter in its simplest form is a mechanical instrument that uses static pressure measured against a reference pressure inside the instrument to display an altitude—essentially a very sensitive barometer. Altimeters are available in both sensitive and non-sensitive versions.

Sensitive altimeters are the ones you're used to seeing, the three-pointer versions with individual hands for hundreds, thousands and tens of thousands feet. Again, we have the choice of certified or non-certified models. The issue here is that the certified models have skyrocketed in price, with the least expensive United going for more than $700. The price goes way up if you opt for an internal encoder to feed your transponder. This configuration was popular for many years in production aircraft, but I don't recommend it. A non-TSO'd altimeter and a TSO'd blind encoder are cheaper and benefit from redundancy; with a combined unit, a failure of either the altimeter or the encoder means the instrument has to come out and be repaired. Not a good trade-off, in my view.

Non-sensitive types are not, as the name implies, either less accurate or incapable of providing sympathy after a bad landing. "There, there...you'll do better next time." Nope, this term simply refers to a lack of hands—as opposed to, say, just a lack of fingers. Non-sensitive altimeters have a single pointer, so that the range of the device—the maximum altitude it's designed to show—is given in one revolution of the pointer. That packs a lot of information into a small dial, especially if you use a 2.25-inch version, making a non-sensitive altimeter much harder to read. However, they're less expensive and make a fine backup to an EFIS. I would not recommend a non-sensitive altimeter for primary use, even VFR.

Vertical speed indicators are the third mechanical flight instrument typically hooked up to the pitot-static system. Most powered aircraft use VSIs, and most non-powered aircraft (gliders) install a more precise variometer. Variometers installed in gliders are typically sensitive to even minute changes in altitude and often have an audio output that varies according to climb or descent rate. Costs for VSIs can range from $150

Sometimes packaging precludes making the panel a traditional six-pack, as this Cozy layout shows.

Photos: Richard VanderMeulen, Stein Bruch, Kevin Wing, Marc Cook to more than $700 depending on sensitivity, size and features.

Failure modes for these basic pitot-static instruments are usually sticky needles after many years, or small leaks in the cases of the instruments. Overhauls are relatively easy and cheap, and used instruments are readily available on the surplus market. As far as certified versus non-certified instruments, the certified instruments often offer a bit higher quality construction. However, many non-certified instruments have proven to be quite reliable as well. Most are American-made, though some foreign-made instruments (Asia and Europe) are also available. Our experience has been that the U.S. and European units seem to be quite good, while the overall reliability of the Chinese units has been somewhat mixed; many customers seem to have good luck with the import units.

This panel will use a 2.25-inch airspeed indicator, TruTrak ADI and altimeter as a backup to a big-screen EFIS. No reason these instruments can't be primary for a VFR aircraft.

It's Lunchtime, So Let's Talk Gyros

Next of importance (and required for an IFR installation) are gyroscopic indicators—normally the attitude indicator and the directional gyro. If you're a day/VFR-only pilot in a day/VFR airplane, you probably don't need a full gyro pack. If you're worried about maintaining wings-level in low-visibility conditions, or think you'd like some help if you ever inadvertently wander into instrument conditions, it might be worth the investment. However, many pilots are well served with just a turn coordinator or turn-and-bank indicator—nothing fancy, just enough to keep the wings level and get you back to VFR conditions. Night is another matter altogether, as we'll discuss shortly.

But first let's talk about IFR equipment. Gyro-based indicators can be either electrically powered or, historically and most commonly, powered by a vacuum source (either engine driven or via an external venturi).

This Murphy Rebel shows a very conservative layout and choice of instruments; all Sigma Tek vacuum gyros, for example. The Mitchell engine gauges, far right, are repackaged VDO items, with good reliability.

One big advantage to steam gauges is their modularity; if one breaks, you take it out and fix it. If your EFIS stops working, you lose a lot of data.

Gyroscopically based AIs have been around for more than 50 years, and their design has changed surprisingly little. Improvements have been made, but the general function has remained fairly similar. Driven by either air or an electric motor, the indicator houses a wheel-shaped chunk of metal spinning at very high rpm with appropriate indications attached to it. As the airplane banks or rolls, the gyro desires to stay in the same spot, and it provides an associated movement on the instrument face.

One limitation to mechanical gyro-based AIs is the fact that the spinning gyro and assembly inside the case normally cannot travel a full 360° of roll and 360° of pitch without hitting physical stops or limits in the instrument. When the gyro hits these stops it causes a "tumble" in which the display will act erratic and be unusable. This is not an issue for normal flying, but any unusual attitudes will typically wreak havoc on the internal gyro mechanism over time. Some gyros are available with a caging function that allows the pilot to reset the gyro to flat/level flight attitude.

Traditional vacuum-driven gyros are still popular in some installations, but the latest generations of mechanical attitude indicators are electrically driven. Several companies are now offering electric AIs with built-in batteries that allow the unit to be run in an emergency free from the aircraft power source. They are much more expensive than their vacuum-powered friends, but reliably is arguably better. Also, the cost

Van's analog engine instruments have proven fairly reliable, and they have the advantage of being very inexpensive. A full collection of them will take up more space than an electronic engine monitor, however.

of a full electric AI/DG combination can be comparable to a vacuum system when you include the cost of the vacuum pump, regulator, filter, plumbing and the fittings.

The DG is sometimes and historically also referred to as a heading indicator. It is similar to an AI in design with the exception that the internal spinning gyro is fixed in one axis and only moves about the lateral axis (yaw), displaying the heading of the aircraft on a simple circular compass rose display. Directional gyros may also be electric or vacuum powered with the preponderance of them being vacuum powered. There are more advanced DGs that use external devices to improve accuracy, but those are not within a typical builder's price range, so the most affordable version is usually vacuum or electrically powered.

Again, our experience with U.S. made DGs and AIs has been very good. The same is true for the European gyros, but our experience with the Chinese imported gyros has been poor. Costs for typical DGs and AIs can range from $400 to $4000 depending on certification, internal batteries, caging, lighting and whether the unit is electrically powered or vacuum powered. Electrically powered attitude and directional gyros are significantly more expensive than vacuum powered ones, but they do not depend on failure-prone vacuum pumps to operate.

Last but not least when it comes to gyroscopic instruments is the turn coordinator and its older cousin, the turn and bank. Both instruments have a spinning gyro inside of them, but fixed only in one axis, meant to give the pilot an indication of turn rate. The turn coordinator senses bank with its internal gyro, and the display indicates a standard-rate turn. The turn and bank purely senses rate of turn and provides no indication as to the roll axis of the airplane. Both instruments will typically have a skid ball installed to show the pilot if the airplane is in a slip or skid, thereby allowing for coordinated turns. These instruments are normally electrically powered, though there have been vacuum-powered versions as well. Again, our experience with American or European instruments has shown them to be the most reliable and consistent.

Powerplant Instruments

If you're building a nice day/VFR fun flier with an affordable engine, and you don't have a requirement to see all EGTs, CHTs, fuel flow and fuel pressures, then perhaps a few strategically chosen engine gauges would be a wise choice. Reading through magazines and looking at all the fancy panels we turn out, you might assume that everyone in the world either has or wants a big glass graphical type engine monitor. Sure they are nice, but do you really need it? One of my favorite airplanes to fly is a friend's all-original 1946 Airknocker. With its 65-horsepower engine, no electrical system and no avionics, the only

Flight Instruments—size and availability

Manufacturer	ASI	VSI	ALT	T/C	T&B	Price
Falcon Gauge	3.125/2.25	3.125/2.25	3.125/2.25 single pointer only	14V or 28V electric 3.125 only	2.25- only, 10-30VDC	$125 - $275
Mid-Continent	2.25		2.25 three pointer	3.125	2.25/3.125	$700 - $3750
UMA	3.125/ 2.25	3.125/2.25	3.125/2.25, both single pointer only		Inclinometer only	$130 - $320

Gyro Instruments

Manufacturer	Model/Series	Type	Volts	Panel Tilt	Lighting	TSO'd	Inclinometer	Backup Battery	Size (in.)
Castleberry	300-EL	Electric	14 or 28V	0 or 8°	Standard	Y	Standard		
Falcon Gauge	GH02V-3	Vacuum		0 or 8°		N			3.125
	GH02E-3	Electric	14 or 28V	0 or 8°	Optional	N			3.125
Mid-Continent	4300 Lifesaver	Electric	10-32V	0-20°	Standard	Y	Optional	Optional	3.125
	4200	Electric	10-32V	0-20°	Standard	Y			2.25
RC Allen	RCA 22	Vacuum		0 or 8°	Optional	Y			3.125
	RCA 26	Electric	14V or 28V	0 or 8°	Optional	Y	Optional		3.125
Sigma Tek	ST 5000	Vacuum		0 or 8°	Optional	Y	Optional		3.125
TruTrak (ADI)	ADI	Electric	12-28V	0°	Standard	N	Standard (in 3.125)	Optional	3.125/2.25

engine instruments are the bare minimums. Tachometer, oil pressure and oil temp—that's it! Sometimes you just don't need all the extra gauges.

Engine gauges, whether electric or mechanical, are very reasonably priced. Many of the instruments we use in homebuilts are copies of automotive products and are priced accordingly. Typical instruments for engine parameters cost $35 to $100. Some of the best values in standard 2.25-inch engine instruments are from Van's Aircraft, which has a line of nice gauges with full needle sweeps in the sub-$100 range. Don't forget when ordering an engine instrument that you will also need to purchase the associated sensor/sender for the specific gauge. If you outfit your aircraft with the minimum required engine instruments, you should be able to get by for about $250 or less. Of course, if you go wild and start purchasing a bunch of other instruments, then you'll soon be reaching the price of some graphical/electrical engine monitors.

TruTrak's ADI was the first low-cost gyro alternative, showing roll as well as rate of climb through the horizon bar. The dashed display is ground track from either an external or optional internal GPS.

Electronic Steam Gauges…What?

I know. This article was supposed to be about traditional instruments. But a number of products don't quite fit the EFIS/EIS definition, but they also don't fit the old steam gauge meaning either. These are the newer generation electronic displays for both flight and engine instruments.

One of the more popular manufacturers of low-cost single instruments is MGL Avionics, which offers "singles," available in a range of sizes and configurations that include singular flight instruments, combinations of flight instruments and a variety of engine instruments. They are neatly packaged in lightweight 2.25- or 3.125-inch instruments complete with a nice graphical display for $100 to $400. The company offers too many options to list

	Notes
	Offer true airspeed, dual-range airspeed and lighted instruments. All instruments non-TSO'd.
	High quality certified .
	Custom range markings available; used by many kit manufacturers.

	Depth (in.)	Weight (lb.)	Price
	7	3.8	$2100
	6.5	2.5	$385
	6.5	2.5	$1100 - $1200
	6.6 - 8.6	2.4-3.7	$3900 - $4700
	6	1.5	$3200 - $3550
	6	4.0	$600 - $900
	7	4.0	$1900 - $2100
	7.125	4.0	$700 - $1640
	4.6	12 oz.	$1100 - $1300

individually here.

There is also a unique manufacturer of a flight instrument. TruTrak Flight Systems has a pictorial turn-and-bank type unit that's a solid-state turn coordinator-style instrument in 2.25- or 3.125-inch sizes. TruTrak also has the attitude direction indicator, which is a quasi attitude indicator and DG in one box. It displays both pitch and roll via solid-state sensors. The ADI is also available in 2.25 or 3.125-inch sizes and can be installed with an optional backup battery. The ADI has proven to be extremely popular even though it's not a true gyro driven indicator. It uses a combination of solid-state sensors along with pitot-static information to display pitch/roll/yaw information along with vertical speed—the so-called pitch bar really isn't; it's vertical speed. The DG portion is actually GPS ground track, available from your onboard GPS (via an RS-232 serial connection) or by an optional internal GPS receiver. Reliability of the ADI has been fairly good overall with few failures.

Stein's Rules for Steam Gauges

Thou shall not waste money needlessly. If you are building a day VFR fun flier and you don't want to expend much money on the panel, then there is no reason to invest more in the panel than the entire airplane is worth! Also, if you buy too many steam gauges you'll be nearly at the same price as lower cost graphical displays, so choose carefully.

Thou shall not install instruments you'll never use or need. If your homebuilt plane has only two cylinders, you don't need to buy a four-cylinder, whiz-bang bar graph analyzer. If the plane uses transparent fuel tanks or has a glass tube sight indicator, there is no need for complex fuel level senders or a fuel computer. Also, if you're building a nice day-only VFR plane for puddle jumping, you don't need three EFIS screens, and if the top speed of the plane is 65 mph with a best climb of 250 fpm, you don't need an airspeed indicator that goes to 250 mph and a VSI with a 4000-fpm

The gyro formerly known as Sporty's: Castleberry is now selling its electric gyro through mainstream outlets for just over $2000. It is a high-quality unit.

The Mid-Continent Lifesaver.

display. (Unless, of course, you bought them used for pocket change.)

Thou shall embrace modern versions of old classics. Many manufacturers are making newer versions of old looking instruments such as attitude indicators, directional gyros, engine instruments and flight instruments, which, in some cases, have digital displays as well. They almost always weigh less, use less electricity and are usually more reliable.

The line between standard round gauges and newer generation instruments is becoming cloudier every day. Even the airlines that always used to have gyro driven "peanut" sized backups are moving toward small graphically displayed instruments. At airshows this summer we will see new instruments from gyro manufacturers that are approaching what would almost qualify as an EFIS, but mounted in a conventional circular hole. Engine instruments are also quickly becoming more advanced and modern, combining multiple functions into single "smart" instruments. There is no reason to be afraid of this new technology.

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. ✢

CONTACTS

Castleberry Instruments
www.ciamfg.com
512/251-5322

Falcon Gauge
www.falcongauge.com
877/543-9961

MGL/Stratomaster
www.sportflyingshop.com
877/835-9464

Mid-Continent Instruments
www.mcico.com
800/624-6845

Mitchell Products
www.mitchellproducts.com
815/678-4299

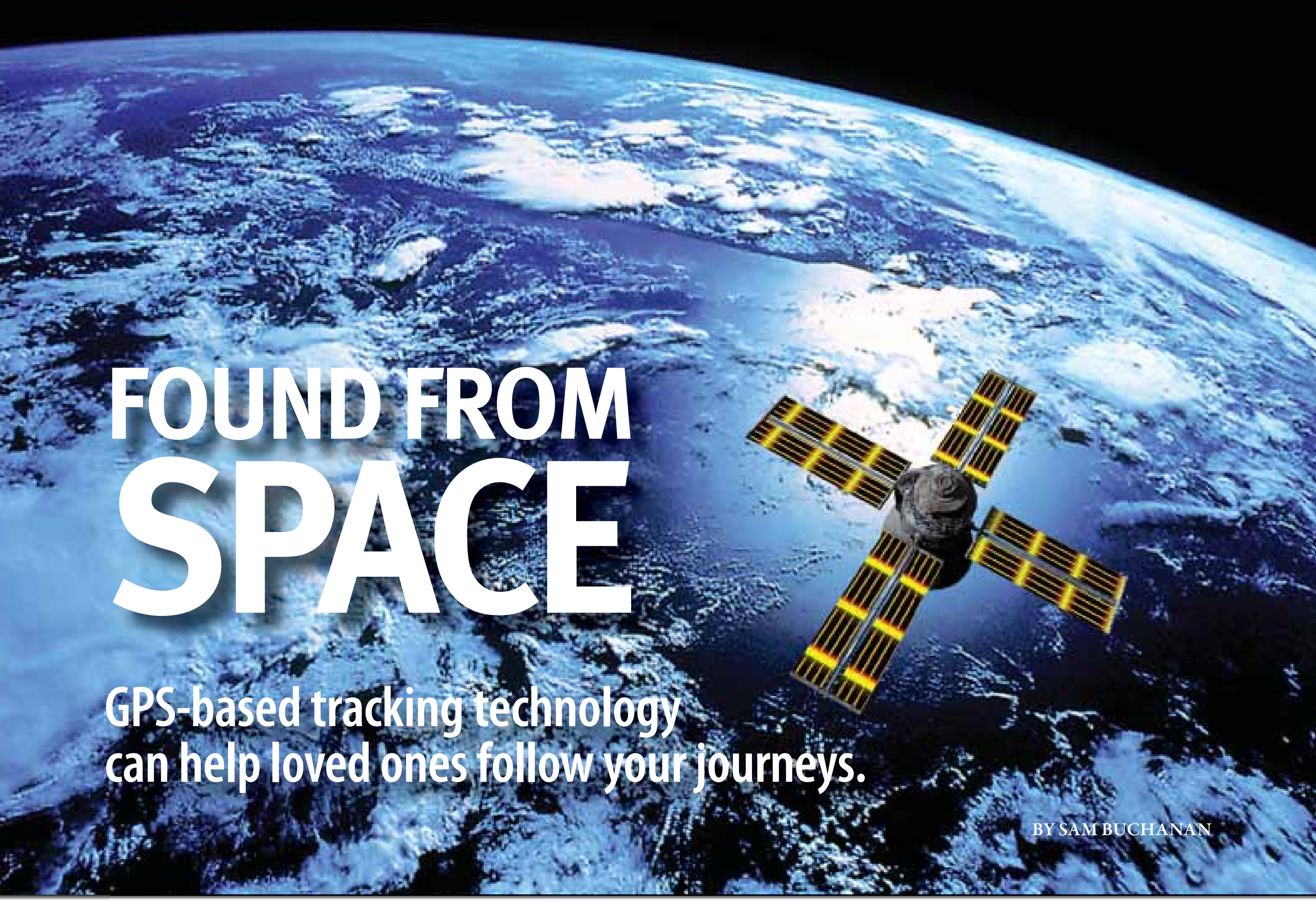
R.C. Allen/Kelly Mfg.
www.kellymfg.com
800-RCA-GYRO

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

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

UMA Instruments
www.umainstruments.com
800/842-5578

Westburg Manufacturing
www.westach.com
800/400-7024



FOUND FROM SPACE

GPS-based tracking technology can help loved ones follow your journeys.

BY SAM BUCHANAN

It's a beautiful VFR day, and because my daughter had been asking for a ride in the RV-6, my second-born and I are winging our way to Grandma's house for lunch. The 50-minute flight is one I have made several times, and is conducted primarily over flat farmland except for about 20 minutes over a thickly wooded national forest. The portion of the flight over the trees has always captured my attention because of the scarcity of potential landing sites in the remote wilderness, but today my stress meter is running a little lower than on previous trips over this region.

Three-dimensional maps are available when the data is ported to Google Earth. Pretty cool, huh?

At home, my wife, who reflects on these flights in a special way when one of the children is onboard, occasionally walks to the computer and takes a glance at the monitor. On a detailed map of the terrain between our living room and Grandma's house is a series of red dots connected by a solid line. Every 60 seconds another dot appears, and the line with the little airplane symbol tagged N399SB is extended in the direction of Grandma's airport. Today, she breathes a little easier because she is watching our track in real time as it progresses across the country to our destination.

Grandma and Grandpa likewise are watching their computer draw the same map, and as they see the flight approaching their nearby airport, Grandma makes one more check on the potato casserole warming on the stove, and then they head for the car for the short journey to the airport and a reunion with their favorite granddaughter. This trip has been more enjoyable than usual for them as they watched our plane depart our home airport and fly toward the lunch appointment.

Watch Your Track

How much would it be worth to you for your loved ones to have real-time access to the progress of your flights? How valuable would it be for anyone with Internet access to be able to promptly see the track of your flight in case of an unplanned conclusion to a flight? How much interest might you have in being able to plop down in front of the computer and retrace your just completed flight to a distant fly-in?

I know these scenarios are intriguing to many pilots. The technology that makes it possible to track our flights real-time without incurring any subscription or access fees is called APRS (automatic position reporting system).

Photos: Sam Buchanan, Big Stock Photo

The Micro-Trak 300 is a miniature, 2-ounce combination GPS data encoder and two-meter transmitter. RF output is 300mw, which is plenty for line-of-sight transmissions over considerable distance. Only GPS data, DC power and an antenna are necessary to complete the APRS rig.

APRS was developed about 20 years ago by very clever amateur radio operators (hams) when digital radio appeared. The technology that makes APRS possible is based on "packet" radio, which is the transmission of bursts of digital data. It really came into its own in the early 1990s with the arrival of inexpensive GPS receivers that made it possible to transmit the exact location of mobile stations via the APRS. In recent years, the addition of full-featured integration with Internet displays such as Google Maps has brought APRS to the point where it can be invaluable to the aviator.

Because APRS operates within the scope of the Amateur Radio Service, a license is required in order to operate an APRS transmitter. The lowest tier of Amateur license, Technician, will provide a pilot with all the privileges and knowledge of FCC regulations necessary to install and operate an APRS transmitter. The Technician exam consists of 35 multiple-choice questions, the body of knowledge required is modest (no Morse code is required), and study guides with the entire question pool and answers are readily available. You can even take practice tests on the Internet. Anyone who has prepared for a Private Pilot License written exam will find Technician exam prep an easy task. A caveat, though; with the Technician license in hand, you may be tempted to delve into the entire fascinating realm of ham radio!

An Inexpensive Technology

A major attraction of APRS for those of us in the Experimental aviation community is the low cost of entry. Because APRS in our application is a transmit-only protocol from airborne vehicles, the equipment requirements are modest and inexpensive. The APRS frequency used in the United States is 144.390 MHz, which is part of the two-meter ham band. This band is supported by a wide-ranging population of "digipeaters" equipped for relaying APRS beacons and transmitting the data to

Obtaining Your Technician License

In order to operate an APRS tracker in an aircraft or other vehicle, the operator must possess a license in the Amateur Radio Service (ham radio). In recent years the requirements for obtaining a ham radio license have been greatly simplified primarily by eliminating Morse code from the first two tiers of license and by abbreviating the exam question pool. Three levels of Amateur Radio license are now available: Technician, General and Extra. The lowest level, Technician, provides all privileges necessary to operate an APRS transmitter on the common two-meter band (144.390 MHz).

There is no reason for anyone with a pilot's license to be concerned about the difficulty of obtaining a Technician license. The exam is very similar to the Private Pilot License written exam, only much shorter and with a much more limited body of knowledge to study. As with the PPL exam, study guides are available that include the complete exam question pool and correct answers. I read the study guide one evening and then began taking practice exams on the Internet. A passing grade on the exam is 75, and I was consistently scoring 90+ on the practice exams, so I tested a week later at a regularly scheduled exam session conducted by local ham radio VEs (volunteer examiners).

The exam required only a few minutes, and I was informed on the spot that I had passed. My call sign appeared on the FCC database three days later, and I was legal to launch N399SB with the tracker pumping out APRS beacons. Two weeks later the paper copy of my license arrived in the mail and is now prominently displayed on my office wall. Not only am I legal to operate the APRS tracker, but I can now join the local Amateur Radio Emergency Service (ARES) network and participate in weather watches, transmit on any frequency within the Technician privileges, and maybe start working on that microwave amateur television station I've been considering! If fuel gets too expensive, I will ration flights in N399SB and instead enjoy ham radio. I'm considering studying for the General license so that my frequency privileges can be expanded even further.

—S.B.

Two examples of inexpensive, homebuilt antennas that work nicely with an APRS tracker. The J-pole flexible antenna is constructed from television twin-lead, which can be installed in a fiberglass airframe or in fiberglass structures such as wingtips on aluminum airframes. The 1/4 wave whip works great on the exterior of aluminum airframes and consists of an element of stainless welding rod potted with epoxy into a PL259 coax connector. Simple commercial com whip antennas can easily be adapted for APRS applications.

Internet portals. We are transmitting APRS data that can travel to the horizon, so only in extremely sparsely populated areas of the country are we likely to be out of range of a digipeater. In most areas, an APRS transmitter of very low power is sufficient to hit a repeater and enter our beacon into the system. If the APRS tracker is operating automatically at preset intervals with no interaction necessary, pilot workload is not affected.

One company that offers a popular line of APRS trackers in a variety of configurations is Byonics. Its Micro-Trak 300 contains a GPS data encoder combined with a 300mw, single-frequency transmitter in a package weighing only 2 ounces! Connect the Micro-Trak to a GPS data feed and an antenna, and the tracker will happily transmit APRS beacons as long as it is supplied with ship's power. The GPS data stream required is the same many of us are sending to autopilots and EFIS units, and can be provided either by a GPS already in the aircraft or an inexpensive stand-alone GPS receiver.

Internet access to our flight tracks is available from several sources, but my favorite is *www.aprs.fi*. This server layers our APRS track over Google Map products and allows us to see our flight track on either detailed road maps, terrain maps or satellite photos. If you have a geek streak, you can dig deeper into the site and explore data tables that reveal the call signs of the digipeaters that captured your beacons and the path taken to the Internet portal. This information provides valuable clues to the effectiveness of our APRS rig at hitting digipeaters and how far our tracker can "see" distant stations.

Let's Talk Hardware

So, now that your interest in APRS is piqued, how much does this electronic wizardry cost, you ask? The Micro-Trak is available at prices from $100 to $180, depending on the model selected. The total cost of your APRS rig will depend on whether you need an additional GPS receiver and whether you use an inexpensive home-built antenna or spring for a commercially available unit. I installed an APRS system in my RV-6 for less than $125, as I pull GPS data from a receiver already in the plane. I also built my own quarter-wave whip antenna from readily available materials and mounted it to the belly of the plane. Another type of antenna can be easily constructed from common television twin-lead cable and installed in a fiberglass wingtip. Even after including $18 for the Technician exam study guide and $10 for the exam fee, the total cost of adding the incredible capability of APRS to N399SB was less than one full load of 100LL.

APRS is not a replacement for an ELT, flight following or prudent flight planning. But it has been my experience that almost without fail, when a pilot sees the trail of red dots on an APRS map for the first time, the safety implications are immediately grasped. The question that follows the first exclamation of "Wow! That is beyond cool!" is "How do I put one of those in my plane?" Not only can APRS enhance the safety of our flights and provide peace of mind for those following them, this aspect of ham radio is just plain fun. And any time we can add another layer of enjoyment and peace of mind on the way to Grandma's potato casserole, the endeavor is certainly worthwhile!

Study guide: Technician Class; FCC License Preparation for Element 2, Technician Class Theory, by Gordon West, 6th edition, effective July 1, 2006 to June 30, 2010. ISBN 0-945053-45-2.

This screen capture from *www.aprs.fi* shows N399SB departing from KDCU with speed, heading and altitude displayed in the bubble. Flight info appears on the web server in a matter of seconds after the beacon is transmitted from the APRS tracker. This particular web site allows the viewer to choose road map, terrain or satellite photo depiction under the track of the flight path.

WEB RESOURCES

APRS Forum on the Van's Air Force Site
www.vansairforce.com/community/forumdisplay.php?f=104

Byonics Micro-Trak
www.byonics.com/microtrak

Installation of APRS Tracker in N399SB
www.thervjournal.com/tracker.htm

Locations of Exam Sessions
www.arrl.org/arrlvec/examsearch.phtml

Map of North American APRS digipeaters
wa8lmf.net/APRSmaps/NorthAmericaLarge.htm

Practice Technician Exams
www.qrz.com/xtest2.html?

Sam's Favorite Flight Tracker
www.aprs.fi

Note: Direct links to these sites will be available at *www.kitplanes.com.*

FIRE IN THE HOLE

Is an extinguisher just extra weight or an essential part of your aircraft systems?

BY BOB FRITZ

There's an old pilot's adage that there's nothing more useless than runway behind you, air above you and fuel left in the truck. To that list I'll add a fire extinguisher still in a catalog.

It's not something we want to think about: You've told your friends and spouse that flying is safe, that there's nothing to worry about. But before every flight on the big aluminum tube, the flight attendants go through their "There are four emergency exits, and oxygen masks will drop…" spiel, so why should you think that the non-verbal approach is appropriate?

Do you need a fire extinguisher? No, at least not until you need it, and then it's a bit late to go shopping! Perhaps you're thinking that it's too heavy or too large to put in an already crowded cockpit. If so, you've been shopping at the corner auto parts store instead of where the NASCAR crowd goes. A tour of Safe-Craft, Inc., one of the leading suppliers to the wingless racer devotees, revealed some refreshing ideas and approaches to the problem of keeping the fire in the cylinders where it belongs.

Above: Want something snazzy? How about designer colors or even something to match the paint job on your airplane?

The Flame Equation

Let's back up a bit and discuss the nature of fire. Contrary to popular opinion, oxygen does not burn; fuel burns when given sufficient heat and oxygen. Take away any one of those three elements, and there's no fire. If the fuel-oxygen

Photos: Bob Fritz and Courtesy the Manufacturer combination generates enough heat, the process becomes self-sustaining. If it doesn't, the fire goes out.

Another wrinkle is that the process of combining oxygen with a material is called oxidation. Do it fast enough, and it's called fire. Do it slow, and it's called rust. In fact, that dull patina that freshly cut aluminum gets in a just a couple of hours is aluminum oxide, another form of rust.

With that in mind, we can see that virtually any material can burn given enough heat and oxygen—witness the oxyacetylene torch. We heat the steel to a bright yellow glow and hit the trigger to inject pure oxygen. Sparks go flying, and a there's a hole where there was once solid metal. The oxygen is not just pushing the molten steel out of the way. If that were all that was needed, any gas would work.

Steel, however, is not a good fuel because when it burns it doesn't generate more heat than is needed to sustain the process. We have to keep the heat of the torch on it and the oxygen trigger down to complete the cutting.

When we cut off the oxygen, the process stops and, when everything cools, we will find lumps of slag, not steel, all over the shop floor. We have literally burned the steel in exactly the same fashion as you would burn a log. The slag is the ash.

At 1.5 inches in diameter, this is not your father's fire extinguisher. The halon 1301 is stored in the central cylinder. When heat breaks the bulb within the red tip, the agent is dispersed onto the flame front in less than 1 second. Install this on the cockpit side of the firewall, direct one nozzle through the firewall into the engine compartment, and the other to the back side of the instrument panel. Have the triggers set for two different temperatures appropriate to the environment, and forget it.

Lest you think that a discussion of metals is going too far in a discussion of burning, I'll direct your attention to magnesium and zirconium. Both will sustain a burn once lit, and it doesn't take much with zirconium. In the days before strobes were used on cameras, we used flash bulbs. The thin wire inside the bulb was heated with a small battery until it ignited in a pure oxygen atmosphere. Now that was a rapid, self-sustaining burn of a metal.

In the more common form a fire occurs because a particular fuel, say, gasoline, ignites at the present temperature, provided by a spark, and combines with the ambient oxygen with enough energy to give off sufficient heat to sustain the process.

I first saw the need for heat demonstrated by my father trying to strike a match when it was -15° F in Colorado. It was just too cold and would cool off the match faster than friction could heat the tip.

Cease Fire

You can see that there have traditionally been only two ways to stop a fire: separate the oxygen and fuel, or cool the fuel/oxygen mixture below the ignition point. Although a blanket of foam will exclude the oxygen, and a fire hose will cool the process, it's a bit difficult to carry either system on an aircraft.

Alternatives around the house include CO_2 in an extinguisher, but that's not reasonable in an aircraft because it disperses too fast when used in the engine compartment. It's less than useful in the cabin because it will create IFR flying conditions when you least need them. That's a minor problem, though, because the cabin occupants will pass out from a lack of breathable oxygen in just a few seconds. You might think you can hold your breath for a minute or two, but breathing CO_2 displaces the oxygen molecule on the hemoglobin in your blood, so you pass out quickly.

Powder-type systems are not allowed in aircraft per the FAA for a couple of good reasons. First, they disperse into the air such as to create a loss of visibility

Don Warren not only designs the SafeCraft systems, he helps assemble them.

The test bed, Warren's high-mileage Mercedes, needs only a 2-pound bottle.

and, second, their corrosive effect will destroy all of the instruments.

At the beginning of the 1900s carbon tetrachloride was used to cool fire by evaporation, but when heated carbon tetrachloride creates phosgene gas. Phosgene was the "gas" in WW-I gas warfare, so scratch that from the list of options. That leaves one other agent that works neither by excluding the oxygen nor by cooling the process. You'll recall that burning is a chemical process of high-speed oxidation, so if we could inhibit the chemistry, we could stop the fire.

Enter Halon

First of all, the use of halon is not illegal. The manufacture of it, however, is against the law because it contains bromine and chlorine, elements that destroy ozone, thereby contributing to global warming. That bit of legislative legerdemain came about for two reasons. Although halon is 16 times more effective than chlorofluorocarbons (aka CFCs) at depleting ozone, its smaller use makes it only 1% of the problem. Also, halon remains the single most effective way to stop a fire without the 2x penalty of weight and bulk imposed by the next best concoction, FE-36. This seems a reasonable compromise given the immediate hazard that fire presents.

How effective is it? Consider that the engines on a Boeing 747 come equipped with two 6.5-pound bottles of H1301. Like so much else on big iron, that second bottle is there in case the first one malfunctions. Now consider that 1 pound is all that's needed to control 50 cubic feet of fire. In short, 10 pounds is enough to saturate the engine about five times over.

But if manufacture is illegal, where does one get halon? Recycling. Halon was used in hundreds of computer rooms and similar facilities that are either being torn down or remodeled. So to avoid just venting the material to the atmosphere, it's bottled and placed in new systems such as those built by SafeCraft. Similarly, when an old airliner is retired, the halon is extracted and loaded into the system on a new airplane. Those computer rooms? They use FE-227 or FE-13. Weight and bulk are not a problem.

What is Halon?

Using the term is a bit like saying cake without specifying what kind. The recipe used determines the final product. The two most common forms of it are Halon 1301 and Halon 1211. The numbering system is fairly simple (there's no test at the end of this, so don't worry if you don't remember it). The numbers simply give you the recipe. In H1301 you have one carbon atom, three fluorine atoms, zero chlorine atoms and one bromine atom.

"Fine," you say. "But I still don't know which to use."

In an election season filled with caveats and prevarications, you'll be pleased to hear a straightforward answer. Use H1301 in fixed-position systems such as in the engine compartment, and use H1211 in handheld units. The reason for this is also easy. H1301 comes out as a colorless, odorless gas and is 50% discharged in less than 3 seconds; H1211 comes out as a low-velocity liquid, allowing you to see where it's going and gives you about 15 seconds to direct it appropriately before it turns to a gas.

Just how dangerous avgas can be is shown in a test for flame propagation done by the FAA where it was found that, "The flash point (by closed cup method at sea level) of avgas is -50° F (-46° C). The rate of flame spread has also been calculated to be between 700 and 800 feet per minute."

That's only about 8 mph, but if you've ever used a fire extinguisher you're probably astonished and/or skeptical of a system that claims to put out a fire in less than a second. Halon is able to do this for a couple of reasons. The flame-front, as noted previously, is moving at slightly more than 10 feet per second, while the contents of the bottle are traveling much faster than that. Also, a 2% concentration is all that's required of H1211 to snuff a fire, while H1301 needs about 10%. So you don't have to bury it as you would with other systems.

With that fast a dispersal rate, and with its ability to contain the conflagration at such a low concentration, you'll be amazed to hear that you can breathe it at a 10% concentration. Remember now, this is possible because it does not remove the oxygen from the fire; it stops the chemistry of combustion. In other words, it goes right to the nature of the fire, high-speed chemistry, instead of the second-level constituents.

Extinguishing the fire is only half the problem, though. Keeping it out is another issue. Consider a fire under the cowl, as might happen with a broken fuel injector feed line. An automatically triggered halon system is so fast at stopping the fire that you might not even know you had one. But if the engine is still running, you're still pumping fuel onto your hot exhaust, and you're going to get a second fire. Now the extinguisher is empty, what do you do?

Why not make it automatic? Not a good idea if the fire occurs on takeoff. Better to let it burn and the engine run while you make a fast return to the airport and then hit the trigger when it's safe to have no engine power. That's why the airlines have a fire-light and a manual shutoff of the fuel; it allows them to decide when to activate the extinguishers.

How large a bottle should you have? SafeCraft's Don Warren has a 2-pound bottle under the hood and a 2-pound bottle in the cabin area. Of course, he's the designer, so he's always changing these and experimenting, but you can see that it doesn't take much halon to cover the problem.

What about the weight penalty? The difference between a 5-pound system and a 2-pound system is about 7 pounds. No, that's not a case of bad arithmetic. The "weight" of the system is the weight of the halon, not the hardware, and to carry 3 pounds more halon requires a bigger bottle.

If you decide to buy an installed system, where should it be mounted? Given the ability to mount the bottle most anywhere you like, and then route some lines accordingly, there's no need to

An especially nice touch is the beautiful bracket. Pull the pin and the bottle with the rings is released for use. Unlike other brackets, this one doesn't rattle.

These fixed-in-place systems can be activated by a pull handle, a push knob or even an automatic sensor. That small red tip is the temperature sensor and can be custom ordered to trigger at one of several different temperatures.

wedge it into the engine compartment.

I checked with a couple of insurance companies and found that they don't offer a discount for having a fire extinguishing system. This seems odd given the obvious benefit. However, the benefit to you and the airplane, not to mention the benefit of a safe landing, will compensate for this oversight on their part.

What Does It Cost?

A fire-extinguishing system costs about the same as the price of one of the top-end fuel-flow valves. If you'd spend $350 on a valve to send fuel to the engine, why not spend about the same to extinguish the fuel that's gotten out of the engine? Let's say you walk in to SafeCraft and ask Warren, "What should I use for my airplane?" When I asked this very question, his reply was, "Use 5 pounds of 1301 for the engine compartment, but mount the bottle inside the cabin or somewhere that won't exceed 130° F. For the interior you need a 1.25-pound bottle of 1211. But note that the FAA says halon is so effective that even this is five times more than is needed for a Cessna 152. So don't discharge more than is needed to extinguish the fire, as you'll exceed the breathable limits."

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RESOURCES

Active Extinguishing
www.raypolandandsons.us/vehicle.html

Amerex Corporation
www.amerex-fire.com/hal_faa.html

H3R, Inc.
www.h3raviation.com

CONTINENTAL PUSHROD TUBE MODIFICATION

Resigned to a leak-free engine.

BY RON DARCEY

The left side of the pushrod tube modification is installed in the author's Continental C-85-12. The tension that pushes against both ends of the tube, holding each firmly and tightly in place, is obvious. Note also the clean, efficient and effective method of this modification and assembly.

When the day finally arrived to overhaul the Continental C85-12 engine that powered my homebuilt, I was determined to rebuild an engine free of oil leaks. Now these little engines are a marvel, but throughout 40-plus years of flying I have always struggled with annoying oil leaks, especially those seeping from the swaged pushrod tubes and rubber pushrod seals. This is a common complaint among cam-at-the-bottom Continental engine owners. Worse, those knuckle-busting ring hose clamps that are supposed to provide the seal leave much to be desired.

Many months before I initiated overhaul on my engine I discovered the Real Gaskets Continental Pushrod Tube Modification kit that replaces the OEM assembly with a unique and effective spring tension method that does away with the swaged tube, assorted rubber seals and ring hose clamps. I was not previously aware of the modification because Real Gaskets does not promote the product, and further research revealed that the aviation press, aviation suppliers, even repair facilities are mostly unaware that the conversion exists.

How It Happens

Why do these seals leak in the first place? It's actually simple: The considerable heat generated under the cowling, especially at the lower end of the pushrod tube, hardens the rubber seals. Hard seals leak. If you want to have no leaks, you replace the seals every few years. Doing so requires that you remove the cylinders as well as disturbing the pushrod tube where it is swaged into the cylinder. Eventually, the swaged end fits more loosely into the cylinder, causing leaks at the outboard end. The swage itself makes the seal; no gaskets here.

Real Gaskets' modification replaces the entire pushrod shroud assembly. The RG-200 pushrod tube is located by a new adaptor plate at the lifter cover (inboard) end. Tension is supplied by an external spring. Silicone seals at both ends of the shroud make the assembly oil tight. What's more, once installed, it's possible to change the seals without removing the cylinder, and each shroud can be serviced independently.

This setup is similar to those used in the later Continentals, and is available for the four- and six-cylinder engines that use this cylinder design. (That would be the A-66, C-75, C-85, C-90, C-125, C-145, O-200, O-300, and GO-300.) It costs $76.50 per cylinder. The conversion kit comes with two pushrod tube assemblies, adaptor sleeves, compression springs and attendant seals, washers, one lifter cover gasket and the Supplemental Type Certificate. The company recommended that I buy the spring compression tool (p/n VSC-1, $24.95), which I did. When the installation got underway, I wondered how these things could be installed without this accessory and a required companion that make a quick, simplified operation.

The Real Gaskets kit seemed like such a great idea that I wanted to know more about the origins of the modification. I had already spoken to the holder of the STC, Harold Carter, at length before I ordered the kit, but we hadn't talked about the kit's background. Sadly, before I could call again and ask, he'd passed away. Carter's son, Chris, now runs the business, but he is not able to provide historical data or who originally designed and engineered the modification. Chris referred me to a Continental engineer he thought might have been involved and who he thought introduced it to his father, but that line of inquiry didn't get far. After months of chasing down one dead-end street after another, I finally realized that the only history I would obtain might surface after the story was published. [Submit what you know to us at *editorial@kitplanes.com*.—*Ed*.]

The pushrod modification kit contains all of the parts required for one cylinder including the STC, parts list, installation and removal instructions, assembly drawing and inspection procedure.

The parts to complete one cylinder include seals, washers, tube assemblies, adaptor sleeves and tension springs (spring compressor tool ordered separately).

The necessary spring compressor tool is used in the installation process with a spring inserted. Forked-end fingers grip the sides of each spring, which is then compressed with the tightening fixture at center.

Putting It Together

While there are complete assembly instructions with the kit, I'll cover my procedure, adding a few suggestions that might prep the operation and acquaint you with it.

You'll definitely need an appropriate set of cylinder base nut wrenches and a fresh set of cylinder base nuts (pal nuts are no longer used). Of course, the simplest installation is if the engine is resting on the stand, but installation is just as easily accomplished with the engine attached to the airplane. If that's your choice, I would suggest cleaning the entire engine with a good, approved cleaning agent. Then remove the spark plugs, intake elbows and intake and exhaust tubes, exhaust stacks and inner-cylinder baffling.

There is no need to remove cylinder head covers, and leaving them attached facilitates handling. Removal is eased by first disassembling the fuel intake elbows (and induction tubes) before attempting to remove the exhaust stacks. *Important: Mark each cylinder for reassembly to its right place in the case and to the connecting rod and wrist pin.*

If your cylinders are destined for rebuild—as were mine—leave the pushrod tubes in place for removal at the repair facility. However, if you're installing the modification to serviceable cylinders, ensure that the piston in each cylinder is at the highest part of the stroke to prevent the rings from being displaced during removal. It's always a good bet to have a friend assist when removing cylinders and, just in case, have a ring compressor on hand in the event that a ring or two is displaced from the piston.

As the cylinder is backed away from the case, ease it to just above the wrist pin. Have that extra set of hands gently tap out each wrist pin with a wood dowel, but only enough to separate it from the rod. Then ease the wrist pin back into the piston and stuff the cylinder with heavy cloth to hold the pistons in place. Set the cylinder aside, case side up.

The REAL Gaskets spring compressor is used to compress the retention spring before installing the lower gasket pack. This step can be done without the tool, but it's more difficult.

Once all cylinders are on the bench, remove the stock pushrod tubes. The tubes are swaged in place, and if they're really tight, care and ease during removal is important to prevent damage to the cylinder hole. With the cylinder head covers removed, use a rubber mallet and wood dowel sized to the diameter of the swaged pushrod tube, and gently tap each tube through the top of the cylinder to loosen it, at which time it will slide free. Some will go quickly, and others might take a bit of careful persuasion (gentle tapping) along the sides of the tube with the mallet.

Next Step: Assembly

Before assembly, it's recommended that you remove all lifter covers and, following the kit instructions, carefully inspect and polish each base mating surface for nicks or damage, including each cylinder base crankcase seal area. Even if it all looks good, use 320 or 400 grit wet or dry sandpaper to lightly polish the surfaces and then clean thoroughly!

Liberally lubricate the base of each cylinder with STP (or any good quality medium lubricant), and then install the new base seals, ensuring that they did not twist. As each cylinder is ready for installation, the crank should be positioned to allow the farthest reach of the connecting rod from the case. With assistance, each piston is eased out (of its respective cylinder) only far enough to expose the wrist pin and aligned with the connecting rod, and the wrist pin is inserted. The cylinder is then eased into position just enough to show a couple of threads of the base studs (about $^1/_8$ inch between the cylinder and crankcase base), and the base nuts are screwed to hold the cylinder in place, ready for the pushrod tube installation. Follow the manufacturer's assembly instructions for each component—seals, washers, collars, compression springs, etc.


The REAL kit includes actual gaskets for the engine side, and no longer relies on the tightness of the shroud swage to prevent leaks.

Both ends of the tubes must be sealed with either Permatex Ultra Copper or #101 RTV silicone (all fully spelled out in the instructions), applied as each is installed. The instructions make the process easy. Using the spring compression tool also makes life simpler. With the spring fully compressed, the pushrod tube is eased into the lifter cover, pushing far enough to allow the cylinder end to be inserted into the cylinder hole. Once the pushrod tube is in place, the compression tool is released, and each lifter cover nut is tightened ever so slightly, as the spring itself is enough to set the seal. Once each set is installed and the cylinder is tightened in place, the compression that makes the seal complete is apparent.

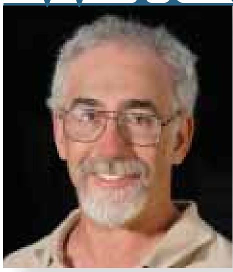

Once both pushrod tubes are in place, release the compression tool and tighten the cylinder nuts to the appropriate torque setting.

Fully compressed, with the cylinder backed approximately ¼ inch from the case, install the pushrod tube by first easing it into the cylinder hole. Once it's firmly seated in the cylinder hole, ease over the lifter cover, ensuring that it is correctly and firmly in place. Remove the spring compression tool.

As I installed the components, I marveled at the design and especially the quality of manufacture of each part. I would suggest a dry run before assembling the first pushrod tube to get the idea of what is involved and how easily and simply it all goes together.

Given the effectiveness of this modification—and how easily it can be installed—it's a shame the product is not better known. Of the few aviation supply firms and engine overhaul shops I do business with, only three are even aware of its existence, and two that once sold the modification no longer list or offer the product—that's because it's gone underground, promotionally speaking. Maybe this story will help. ✈

For more information on Real Gaskets Corporation, call 423/543-6194, or visit www.realgaskets.com. There is a direct link at www.kitplanes.com.



Directional stability and flight performance.

For the past few months, we've been covering various aspects of longitudinal flying qualities, but pitch is not the only axis we must concern ourselves with to make the airplane fly well. Yaw and roll are also vitally important. Accordingly, we now move on to the lateral/directional stability and flying qualities of airplanes, including the effects of dihedral.

Ideally, an airplane trimmed for straight and level flight should continue in straight and level flight indefinitely. If it is disturbed, it should recover. To do this the airplane must not only be stable in pitch, it must be stable about two other axes. The first axis is the directional, or yaw axis. If the airplane's nose is yawed left or right by turbulence or a rudder input, the yaw should cause an aerodynamic yawing moment that tends to point the nose back into the wind. The second axis is the roll, or lateral axis. If the airplane is rolled from level flight, we want it to generate a rolling moment that will tend to level the wings.

Unlike pitching motions, which occur about a single axis, rolling and yawing motions are cross-coupled. When a stable airplane is disturbed in roll or yaw it will respond by both rolling and yawing, even if the initial disturbance was a pure roll or a pure yaw. The roll and yaw behavior is referred to as its lateral/directional characteristics, whichplay an important part in determining whether it is a safe and pleasant machine to fly. Poor lateral/directional characteristics can make precise flying difficult or impossible, and can also lead to wallowing motions that will tax even the strongest stomach.

Handling is a compromise. Strong directional stability makes for better cross-country aircraft but can weaken responsiveness. Pitts pilots don't need no stinkin' stability.

Sideslip

When an airplane is in coordinated flight, the airstream approaches the airplane from dead ahead. If the nose is yawed away from the wind, the angle (in the top view) between the centerline of the airplane and the incident airstream is called the sideslip angle. Both yawing and rolling the airplane generate sideslip. It is easy to see how yawing the airplane generates sideslip. How roll generates sideslip is a little more complex.

If an airplane is in level flight, the lift of the airplane is acting up, the weight of the airplane is acting down, and the two forces are in balance. If the airplane is rolled, the lift is now directed in the direction of the bank, and is no longer acting in a direction directly opposite to the weight. While the lift is still acting at 90° to the span-wise axis of the airplane, the weight, which is still acting straight down towards Earth, is now pulling the airplane toward the lowered wing. This causes the airplane to slide sideways, or sideslip, in the direction of the roll. This situation will persist as long as the flight path of the airplane remains straight. In a coordinated, steady-state turn, the component of the weight acting toward the inside of the turn is balanced by the centrifugal acceleration of the airplane on its

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

curved flight path.

It is the effect of sideslip on the rolling and yawing moments generated by the airplane that determines its directional/lateral characteristics. We will discuss each axis individually, and then turn our attention to coupled directional/lateral effects.

Directional Stability

The tendency of an airplane to swing its nose back into the wind in response to a sideslip is called directional stability. It is also referred to as "weathercock stability," because the airplane behaves like a weathercock, which always tries to point into the wind. If the airplane tends to point its nose back into the wind in response to a sideslip, it is directionally stable. If it tends to yaw away from the wind, increasing the sideslip angle, it is directionally unstable.

Good directional stability is vital if the airplane is to have acceptable flying qualities. Nothing makes an airplane unpleasant to fly sooner than weak directional stability. If the airplane has insufficient directional stability it will be difficult to coordinate turns, and the airplane will have a tendency to wallow and wander in flight. Flying a directionally unstable airplane is virtually impossible without the aid of sophisticated (and incredibly expensive) flight-control computers.

It is worth noting that poor directional stability is a relatively common defect in homebuilt airplanes, particularly early versions of airplanes designed to go fast. Designers, in an effort to minimize wetted area, try to make the vertical fin as small as possible. Two of the most popular fast kit airplanes on the market today had their fins and/or rudders enlarged early in the life of the design. While no one has ever made a definitive statement about why this was done, I will wager that the airplanes were much more pleasant to fly after the fin-enlargement modifications.

Making the fin bigger probably did not have a significant effect on the speed of the airplanes. The amount of wetted area that must be added to a marginal-sized fin to make it an adequate-sized fin is quite small compared to the wetted area of the airplane as a whole. Also, an airplane that is directionally marginal will tend to hunt laterally and end up spending much of its time flying with some sideslip. This sideslip causes drag, so in real-world operation the directionally stable airplane with the larger fin may actually prove to be slightly faster than the small-finned machine.

Fin Effects

Three factors determine the effectiveness of the vertical fin at stabilizing the airplane directionally. The first is the area of the fin. The fin stabilizes the airplane by producing side force on the aft end of the airplane. When the airplane sideslips, the fin is presented to the air at an angle of attack. This causes the fin to develop lift that pushes the tail of the airplane sideways, away from the incident wind. This fin side force is what swings the nose back toward the wind. The larger the fin, the more force it can produce at a given sideslip angle, and the more it will stabilize the airplane.

The second factor affecting the directional stability of the airplane is the tail arm. The tail arm is the distance between the center of gravity and the aerodynamic center of the vertical fin. The stabilizing yawing moment that the fin produces when the airplane yawed is the product of the fin side force and the tail arm. Increasing the tail arm increases the lever arm over which the fin side force can act to counteract the yaw. The longer the tail arm, the more directional stability the airplane will get from a given vertical fin.

A third factor affecting the directional stability of the airplane is the aspect ratio of the fin, which determines the slope of the fin's lift curve. In other words, it determines how much the lift coefficient of the fin will change in response to a change in fin angle of attack. Increasing aspect ratio increases lift-curve slope, so a high-aspect-ratio fin will provide more directional stability than a low-aspect-ratio fin of the same area. Unfortunately, high-aspect-ratio fins also stall at lower sideslip angles than lower-aspect-ratio fins. This can cause problems, because if the fin stalls, the airplane may become directionally unstable at sideslip angles above the fin stall angle. Fin stall can lead to a condition known as "rudder lock," where the airplane achieves a relatively high sideslip angle because of the loss of directional stability caused by the fin stall, and the rudder forces produced by the sideslip tend to force the rudder hard over. The standard fix for this condition is the highly swept dorsal fin extension, which is a feature of many airplanes. The dorsal fin acts much like the leading-edge extensions or strakes on modern fighters, and delays the fin stall to a higher sideslip angle.

Flutter worries also tend to keep fin aspect ratios down, but with careful design, a relatively high-aspect-ratio, flutter-free vertical fin can be designed. One example of the use of a high-aspect-ratio vertical fin to provide good directional stability is the Questair Venture.

Body Effects

Fuselages are almost always directionally destabilizing. So are engine nacelles and any other body that protrudes ahead of the c.g. of the airplane. In general, the longer the nose of the airplane, the more destabilizing it is. Thus, long-nosed airplanes must have larger vertical fins and/or longer tail arms to achieve the same directional stability as short-nosed airplanes. This is important to the designers of airliners and fighters, which tend to have long noses. Nose effects are particularly troublesome to fighter designers. At the high angles of attack used in air combat maneuvering, not only is the size of the nose important, but also relatively minor changes in nose shape can produce large changes in the high-angle-of attack directional stability of the airplane. On some fighter designs, the unstable yawing moments produced by the nose at high angles of attack can overpower the fin and rudder, leading to loss of control, usually through a rapid yawing motion called "nose slice."

Yaw Control

In addition to directional stability, the airplane must have acceptable yaw control. While banking is the principal method of inducing a turn, yaw control is needed to coordinate turns and keep the

Photo: Kevin Wing

airplane tracking the runway heading on takeoff and landing. It also allows the pilot to command a steady-state sideslip. Adequate yaw control is vital for safe crosswind takeoffs and landings, and to enable the pilot to control torque and P-factor when the airplane is climbing. It is also crucial when the airplane is flown at or near the stall, as it provides a way of preventing the airplane from entering a spin if it drops a wing.

The rudder provides yaw control. On most airplanes the rudder is a plain-flap control surface that forms the trailing portion of the fin. Deflecting the rudder changes the lift of the fin and produces side force on the tail, producing a yawing moment. The rudder is also one of the primary controls that is used to recover from a spin.

Rudder Effects

If the pilot removes his feet from the rudder pedals, the rudder is free to float with the wind. Allowing the rudder to float decreases the effective area of the fin, because the rudder, which is floating with the wind, is producing less directional stability increment than it would if it were fixed. It is quite possible to produce an airplane that is directionally stable with the rudder fixed, and directionally unstable with the rudder free. This is undesirable, and can be fixed by either aerodynamically balancing the rudder to reduce its floating tendency or by increasing the size of the fixed portion of the vertical fin.

Many WW-I fighters had all-moving vertical fins. Not surprisingly, some of them also had rather exciting directional characteristics, which, in the hands of an expert, made them extremely maneuverable, and in the hands of a less-skilled pilot often proved lethal. All-moving fins are much less common today, and appear on a few high-speed military airplanes such as the SR-71 and the F-117, and a small number of light airplanes such as the Volksplane. While all-moving fins are workable on light airplanes, the designer must be careful to ensure that an all-moving fin has little floating tendency. If the fin has a large tendency to float with the wind, it may, in effect, cease to provide any directional stability at all if the pilot releases the rudder pedals. This could be most unpleasant and should definitely be avoided. Although all-moving fins have been made to work on light airplanes, they offer little advantage, and the potential for serious directional stability problems suggests that they should be avoided in favor of a conventional fin-rudder combination.

Propeller Directional Effects

An operating propeller, in addition to producing thrust, produces a side force if the airplane is sideslipping. This effect causes the propeller to act directionally like a small vertical fin. If the airplane is a tractor, this propeller's normal force is directionally destabilizing. The airplane will be less stable directionally power on than power off. While this effect is small for typical light airplanes, it can be quite large for long-nose, high-powered airplanes such as WW-II fighters and some of the recently developed turboprop singles. It can also be significant for high-powered twins with long engine nacelles. If the airplane is a pusher, with its propellers behind the c.g., then it will be more directionally stable power on than power off.

The spiraling slipstream of a tractor propeller also causes the well-known P-factor, a yawing moment caused by the swirl component of the propeller slipstream impinging on the vertical fin. The swirl causes the prop wash to hit the fin at an angle, inducing lift on the fin. This lift causes a yawing moment even when the airplane is flying at zero sideslip. To maintain zero sideslip, coordinated flight, the pilot must deflect the rudder to counteract the effect of the propeller slipstream and eliminate the P-factor yawing moment.

Next month, we will continue our discussion of lateral/directional characteristics with a look at the roll axis, including the effects of dihedral and sweep. ✈

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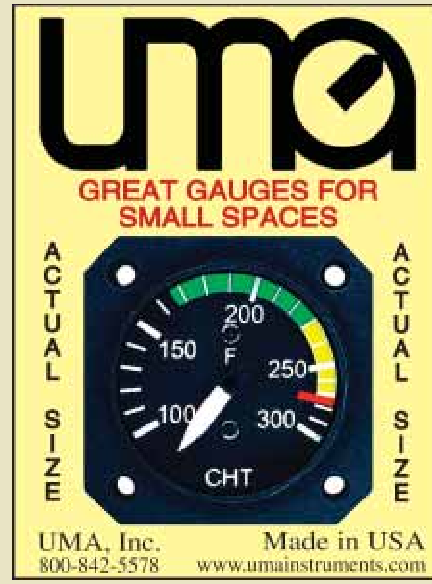
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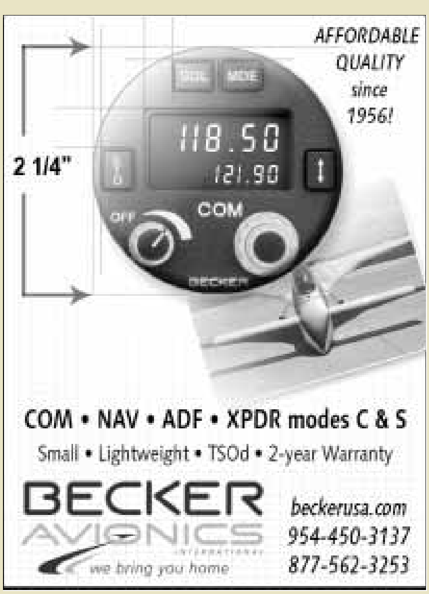
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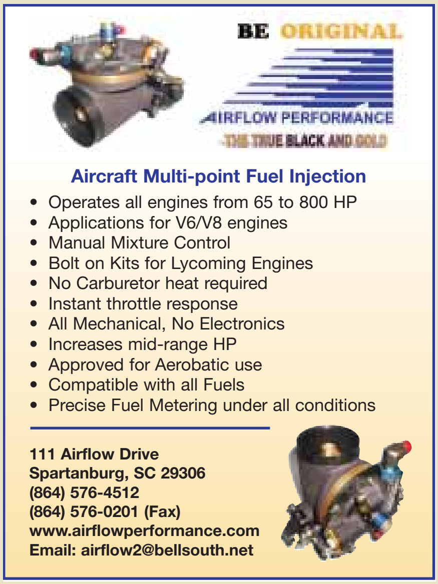
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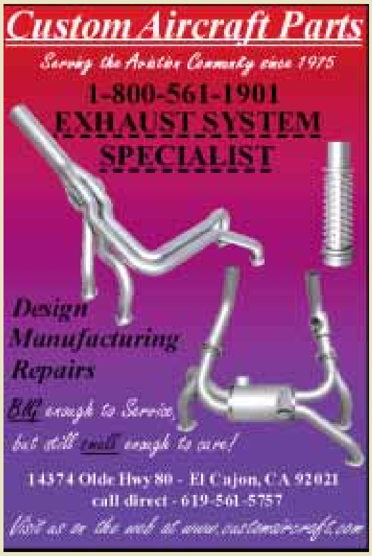
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Ron Berthiaume's GlaStar

I started construction in February 1998 and completed the project in June 2006. Many thanks to my wife, Natalie, for her patience and understanding, to my friends and family for helping when requested, and to the GlaStar community. The plane is powered by a Lycoming O-320 D1F swinging a metal Sensenich prop. It is IFR equipped with a Vision Microsystems engine monitor, Garmin radio stack and an all-electric panel with dual batteries. The interior is complete with every item covered in leather or cloth. The graphics are by Aerographics Design, and my son drew the eagle's head in time for Sun 'n Fun 2007. My technical counselor and test-flight pilot was Joe Gauthier.

RONBERTH@NETZERO.NET

Jim Wallace's RV-9A

After three years and six months, on October 31, 2007, my Van's RV-9A (N339PJ) flew for the first time with me at the controls. When I first flew 339PJ, I had a whopping 140 hours total flying time accumulated over 20 years. The first flight was uneventful, except for a plugged pitot tube. Seems a bug had set up housekeeping in the tube. It was evicted shortly after we got back on the ground. My Garmin 396 gave me ground speed, so I was able to bring PJ in for a smooth landing despite not knowing my exact airspeed. PJ is equipped with a Lycoming O-320 engine, a Sensenich fixed-pitch prop, a Garmin SL40 com radio, a GTX 327 transponder, a Garmin 396 GPS, a Dynon EFIS-D10A, an Advanced Flight 2002 engine monitor as well as a TruTrak flight control system and an analog airspeed indicator. Shortly after finishing the project, the painting fever got hold of me, and I now have what I think is not only a beautiful plane, but also a beautiful paint job. Thanks to my wife for her input, a few friends and, last but not least, the painter, who kept the paint job going the way I wanted it to go. My thanks also to Van's Aircraft's helpful consultants and to Stein Air for making the wiring task easier. A special thanks to Steve Johansen, who has built three RVs and was always there to help when I needed it. As of the end of 2007, I had 90+ hours of happy flying time. Here is hoping your dreams turn out as well as mine.

AUMSVILLE, OREGON
JWALL53661@AOL.COM

Richard Simpson's Aeros Sky Ranger

N590SR first flew on March 3, 2007, from Williamson-Sodus Airport after 300 hours of building. The Sky Ranger is a 631-pound (empty) fabric-covered aircraft. I chose the Rotax 912 ULS 100-hp engine and put the aircraft in the Experimental Light Sport class. Short-field performance is great. Special thanks for all their help and expertise to my wife, Linda, Bob Schutte, Sky Ranger dealer and builder Charlie McInerny and aircraft mechanic George Lucas for the nose art—a leprechaun—and the name *Murphy's Law*.

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BUILDERS SHARE THEIR SUCCESSES

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.

I'm an amateur and loving it.

When it comes to building airplanes, technically I'm an amateur—and I'm perfectly content with that characterization. You see, our "special" airworthiness certificates afford us some pretty amazing flexibility, and I'm having a real blast taking advantage of it. Many factors drove me away from certificated airplanes and toward the amateur-built side of the fence, and every once in a while my appreciation for those factors is renewed.

Every year when I conduct my own condition inspections, as I take my sweet time and give my airplane the attention and loving care it deserves, I savor the notion that quality and safety are in my control. No shop is rushing me out the door or milking me for my last dollar. If I happen to take two weeks of my own time to finish, going over every last inch and detail, the only cost to me is my time and sweat. And let's face it, as was the construction of this wonderful airplane, the process of maintaining it is a labor of love. Whether it's the annual condition inspection or just lubing the tailwheel, this same degree of patience and care goes into the task.

The new horizontal stabilizer, installed on Dan's RV-7. Through experience, this one is better built than its predecessor.

Look What I Found

During my most recent condition inspection, while doing my "every inch" inspection of the tail surfaces with a mirror and flashlight, I discovered what appeared to be tiny cracks in the front spar of my horizontal stabilizer. The cracks were so small that they could just as well have been flecks of dirt, but they did catch my attention. After picking at the area with my finger, I still couldn't tell if they were cracks in the structure or just the primer. I had to sand and file away the area a bit just to confirm, and even then I wasn't positive. I ended up drilling out a rib to be sure. Long story short, they were indeed cracks, albeit small, and the cause was more than clear—there was not enough of a relief notch at a bend. Simple stuff.

The cracked area was heavily doubled, but I'm not interested in taking any chances. Replacing the spar was what the doctor ordered, but replacement would be a far more involved task than simply building an entire new horizontal stab. I ordered the parts, and a week later I was mating the shiny brand new HS with my fuselage.

It's a bit humbling to find fault in your own work, but I have no qualms about it. That HS was the first component I built on this airplane, and in terms of "education and recreation," it definitely was more of the former in my case. Having hopped into the project with essentially no prior experience, I'm not surprised that I overlooked a small detail at that phase (in my defense, the plans didn't call for a relief notch in that area until a later revision). It's not something that would have downed the airplane, but it's definitely not something I was going to

Dan Checkoway *is among his many talents—high-falutin' computer programmer, entrepreneur, musician, EAA Tech Counselor and workshop teacher—a repeat offender: In addition to his Van's RV-7, which had racked up more than 1600 hours by April 2008, Dan has begun construction of an RV-8. He swears that it'll be light, simple and only as well equipped as it needs to be.*

Photos: Dan Checkoway

This is a 19-gallon fuel tank made by RCI—before modifications. It's installed in place of the passenger seat for long solo cross-country travel. The extra capacity enables completion of 1000-n.m. legs without breaking a sweat. Personal bladder solution not included.

let go without remedy.

Coupled with the humility of finding the miscue is the satisfaction of having caught the problem (it was extremely obscure) and possessing the ability to crank out a higher quality replacement in short order (three days). OK, I guess that is enough patting myself on the back, but I'm serious about it having been a positive experience. Even better was that I did it myself, as an "amateur," without the intervention of the Feds. I laugh when I consider how much that repair would have cost if it had happened to my old Mooney!

More Freedoms, Reveled In

I've renewed my appreciation for other benefits of my amateur status recently as well. I admit I'm having a love affair with the freedom to add and experiment with new systems in the airplane without the burden or hassle of approvals and paperwork. I have absolutely no desire to tweak things to the point of negatively impacting safety or reliability, but I proudly take advantage of the privilege to make changes without the feds watching over my shoulder.

Case in point: I added a removable cross-country fuel tank to my airplane, which came in handy when it extended my range on a recent coast-to-coast trip. It was a fun little project, designing and building a mount for the tank and plumbing it into the fuel system. On the trip I did discover some things I'll want to modify, but I revel in the fact that I don't need permission or approval from any sort of government entity to complete the mods on my own.

Another example. I'm in the process of installing an inexpensive ham-radio-based APRS system in the airplane (see Sam Buchanan's story about this technology on Page 43.) I'm making my own antenna for pennies, and I'll be able to experiment with the system until I'm content with its performance. Again, Big Brother is nowhere near my shoulder. I'm not hiding anything—I just enjoy not needing to jump through any hoops. Common sense rules, as well it should.

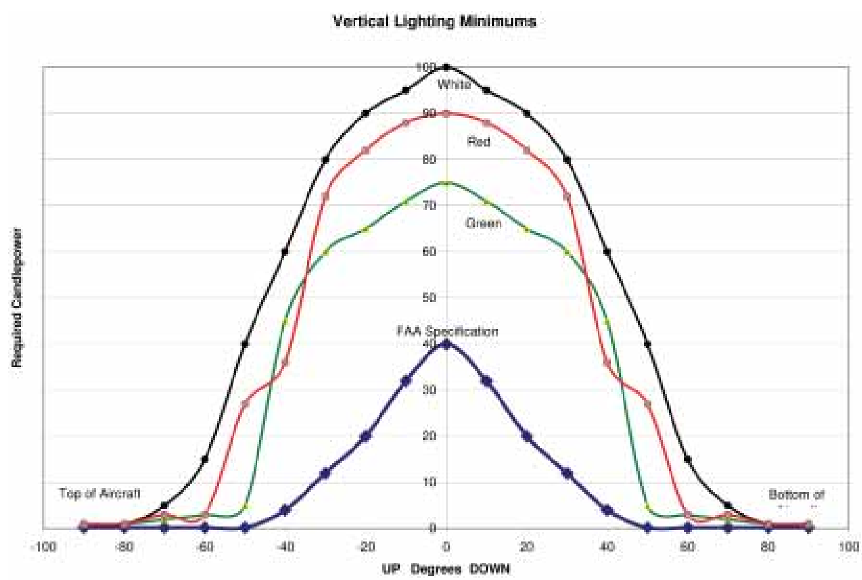
As amateurs, we're trusted simply to be responsible with these types of freedoms. I take it seriously, because it's something I'd like to take advantage of for decades to come. ✈

Optics 101: We start the LED nav light series.

I'll admit it right off the crack of the bat: I was one of the physics undergrads taking optics at San Diego State who made the top half of the class possible. I mean, I was a semiconductor physics major. For what did I need optics? And my grade reflected it!

Well, optics is a wonderful window on how microwave antennas work, and dozens of optical phenomena have their exact analogs in this field.

Starting now is a series of columns on the new high-powered LEDs and how they might be used as nav lights. And because the nav light specifications were designed and published in the 1930s, anything that we can come up with for modern devices should beat the specifications by a country mile.



Graph 1.

What the FAA Wants

Nav lights were the FAA's first attempt at keeping aircraft separated at night. Otherwise, the forecast is for widely scattered aluminum. Taking our lead from the boating world, we adopted their nav light scheme of red lights on the port side of the vessel (port wine is red, remember ground school?), which leaves green for the starboard wing and white for the light on the tailfeathers. Theory said that you would be able to see another aircraft operating in your general vicinity at night and avoid. That was long before Cirrus and 200-knot patterns.

Also, the FAA wanted us to see certain lights at certain angles and not at others. If I were the "target" aircraft, the FAA would want you to see the white light on my tailfeathers at an angle of at least 70° either side of a direct "hit" on the tail, but not much beyond 90°. Similarly, you would need to see my bright wingtip lights from a direct hit on the nose, very little aft of the wing and about 10% either side of a direct hit on the nose. Thus, if you were approaching me from the rear, all you would see is white light. Approaching me head-on, you would see both red and green lights for about 10% either side of a direct nose-on hit. For those of you for whom graphs are easier to understand than words, I'll illustrate what I believe CFR 14 FAR 23.1391 and 23.1393 are telling us.

As a final data point before we get into the graphs, I chose a new member of the "high-power" LED family from a company called LedEngin, Inc. The devices chosen for this project are 3-watt LEDs with attached thermal conductive pad, part number(s) LZ1-10?103, where the ? is replaced with an R (Red), G (Green) or CW (Cool White), the three colors we need for position lights. The cost? About $9 apiece in onesie-twosies. If you want brighter lights, they have 5- and 10-watt mooses that are painful to look at and even more painful to buy.

The attached thermal pad was extremely interesting, in that most manufacturers connect their thermal pad to one of the diode elements, generally the anode. That makes mounting the device directly to the airframe ground extremely difficult, because with a positive battery supply, the anode is the terminal

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.

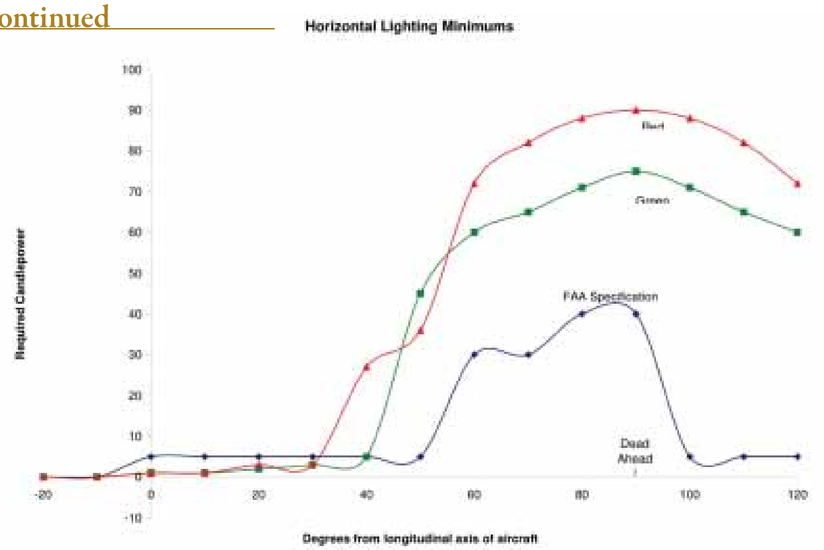
we have to feed positive current to. With an electrically insulated yet thermally conductive mounting pad, that problem disappears. These little rascals will mount directly to the wingtip flange with plain old 4-40 screws, nuts and bolts.

Light Visibility

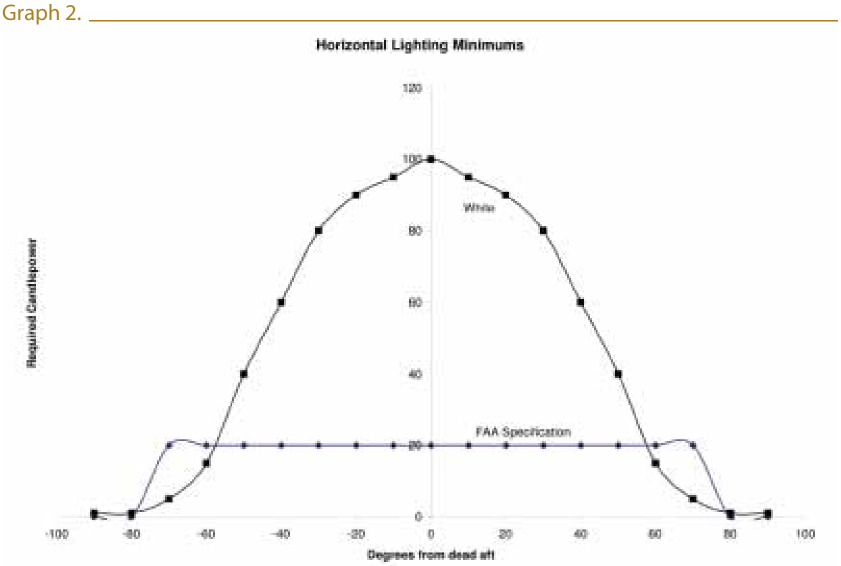
Let's now turn our attention to the graphs provided with this article. Graph 1 shows the vertical lighting minimums, how far above the target aircraft and how far below should we expect to see lights. Obviously, a dead-on hit is the worst situation, so the Feds wanted a minimum of 40 candlepower directly forward of either wing or aft of the tail. The devices we have chosen far exceed this minimum, with the worst being green at 75 candlepower and the best being white at 100 candlepower. When you get above or below 45°, there isn't as much light required, as a direct hit is nearly impossible. However, as the graph shows, even a single LED is well above the FAA minimums.

Graph 2 shows the horizontal lighting minimums for the wingtip lights. Again, the worst possible scenario is a dead-ahead hit, as the sound generated will far exceed most laws regulating noise. Joshing aside, the Feds say that you have to have at least 40 candlepower directly forward, but you can't have too much overlap with the red and green lights at directly forward. With a suitable light baffling mounting plate to control the spillover and reflect this light to the sides, you can pick up that deficiency in the left part of the graph. How? Hey, remember, I'm the guy who lights the light. The optics are somebody else's problem. Just remember that polished aluminum is your friend.

Graph 3 shows the horizontal lighting minimums for the taillight. Note that for a single LED, we have way more candlepower than is necessary dead aft, but we don't have quite enough out at the +/-70° points. Again, a clever optics guy could likely figure out a way to deflect some of that excess boresight light and pass it out to the edges so that we need only a single LED hanging out at the tailfeathers.



Graph 2.



Graph 3.

Andrew Sarangan did a good article about the nav lights on his Europa. You may wish to take a look at his way of doing things to get an idea of where I am headed. However, he chose to do a very complicated power supply using thermistors, current sensors and heat-producing linear regulators.

I'll show you next month why I think a switching power supply is the way to go and why that is the optimum solution. Until then, you might want to go to Mouser and get a couple of these LEDs to play with. My only suggestion is that you put a light dam between the LED and your face when you first turn the diode on. These suckers are bright.

Stay tuned. We may be able to do the landing light for less than a tenth of the $500 those suckers were going for last year at Oshkosh. ✈

Resources

Code of Federal Regulations, Title 14
www.access.gpo.gov/nara/cfr/waisidx_08/14cfrv1_08.html

LedEngin, Inc.
www.ledengin.com

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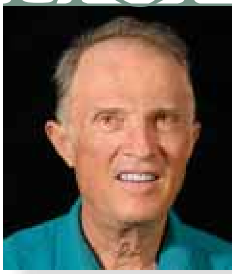

Meet the all-metal Gobosh G700S LSA.

From the name, you might guess that Gobosh Aviation—the company that imports a line of Light Sport Aircraft (LSAs)—is Asian or European. In fact, Gobosh is based in Moline, Illinois, and was founded by young American aviation businessmen. Tim Baldwin, president, and Dave Graham, vice president, head the company that imports low-wing LSAs, the all-metal Gobosh G700S and the composite G800XP. Gobosh, by the way, is a shortening of the entrepreneurial expression "go big or stay home."

Baldwin and Graham have gone big in several ways. First, they are promoting their aircraft as the luxury end of the LSA spectrum. For example, even the least expensive Sport Edition G700S includes standard six-pack instrumentation, Garmin GPS and transponder, wheelpants and leather seats. Another example of starting with a splash is the recent addition of the composite G800XP two-seater to the line.

Gobosh demo pilot Tony Settember checks out pilots in the company's G700S.

Mods for America

The G700S line is made in Poland by Aero, a successful company founded in 1994 and producer of several type-certified light airplanes for the European market. The 700 is an Americanized version of Aero designer Tomasz Antoniewski's certified AT-3.

To qualify as an LSA and therefore become eligible for Sport Pilots to fly, the wingspan was increased (no doubt to meet the 45-knot maximum clean stall requirement). Other changes for the U.S. market were the addition of winglets, American avionics and a substantially different panel layout including the standard six-flight-instrument cluster.

Some G700 Details

Like most factory-built Light Sport airplanes (SLSAs)—both domestic and foreign—the Gobosh planes are powered by the Austrian 100-horsepower Rotax 912S geared four-banger. Despite alarming recent price increases (due to alarming changes in euro/dollar exchange rates), the Rotax 912 series is likely to remain dominant in the LSA market. That may happen (at least until Cessna's Skycatcher appears in great quantities with its Continental O-200-G engine) because of the 912's high power-to-weight ratio, reputation for durability and recommended 1500-hour TBO. A three-blade Elprop composite propeller absorbs the Rotax power.

The G700 features include a 41-inch-wide cabin, wonderful cockpit visibility, dual controls, mechanically operated split flaps, a stabilator for pitch control and 18.5-gallon fuel capacity. With full fuel, the remaining payload before you hit the 1320-pound LSA maximum is 390 pounds. That results from an empty weight of 820 pounds, which is more than many other SLSAs. But Gobosh notes that empty weight includes its standard full bag of instruments and avionics.

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

Photos: Dave Martin and Jim Koepnick Courtesy EAA

There are separate gauges for airspeed, altimeter, attitude, turn and bank, VSI and heading plus a com transceiver, GPS, transponder and engine instruments.

The Sport Edition is intended for day VFR flight only. The next-level Elite Edition adds a PS Engineering PM3000 stereo intercom, two-tone paint (white plus red or blue) and matching two-tone leather seats. (The basic Sport Edition comes in white with a choice of vinyl stripes plus gray leather.) The top Elite Plus Edition includes a nav/com with CDI and upgrades to a Garmin 396 with XM Weather radio.

The airframe warranty is two years or 400 hours. Insurance and financing are available through Gobosh. Prices as this is written are $109,900, $123,700 and $129,990, respectively, including shipment to the U.S., assembly and FAA registration.

Let's Fly It

Following a walk-around, Gobosh demo pilot Tony Settember and I climbed aboard. This G700 Elite Edition had flown a few hours earlier, so we skipped the famous Rotax burping-the-engine-oil check. A castering nosewheel and differential toe brakes, as found on many other LSAs, allow short-radius ground handling. Turning and braking require only a gentle touch with the toes.

The weather at Sebring, Florida, was clear and windy with gusts down the runway to more than 20 knots. Therefore, we were in no hurry for liftoff during the takeoff run, and Settember advised climbing at 65 knots for more solid control instead of the best-climb 58 knots. The climb rate was close to 750 fpm with the two of us and 14 gallons of fuel—about 100 pounds under maximum gross weight (1320 pounds).

Outside the traffic pattern, I got the feel of the 700S with a few clearing turns, and we spent considerable time checking stall behavior.

First I tried a partial-power (5000 rpm) departure stall. The electrical stall warning came on at 40 knots with 3 to 5 pounds of right rudder pressure approaching the stall and 2 to 3 pounds of back stick. The stall itself was docile and without a wing drop.

An approach stall was sampled with idle power and 15° of flaps. Trimmed for a 50-knot, half-flap approach, slowing toward stall speed required lots of back pressure and yielded obvious buffeting. Again the warning sounded at 40 knots, and the stall break occurred at 38 indicated. Easing back pressure broke the stall, and altitude loss was minimal even without adding full power. Wide-awake pilots should easily recognize an approaching stall in this airplane, at least if they are keeping the slip/skid ball near the center.

Settember demonstrated on-the-edge slow flight at 3800 rpm, noting that at 40 knots, banks up to 25° are easily controlled. He yanked and pulled for an accelerated departure stall at 60° of bank, raising the stall speed 41%. Still, nothing alarming occurred, but I recommend trying this first with a Gobosh checkout instructor and at a reasonable altitude. Slow flight was predictably comfortable, with or without trimming for it. The mechanical trim wheel is in the console between the seats.

At maximum continuous power—5500 rpm on the Rotax tach—we indicated 115 knots at 5700 feet with outside air temp at 60° F. That works out to 120 knots true airspeed. At this speed and power setting, I removed my headset and found the cockpit to be relatively quiet. Flying with headsets is of course the way to go, but you could carry on a conversation without them.

I tried the stick-free pitch stability check. Two phugoid cycles after pitching up or down got us back to trimmed attitude and airspeed, and the damping was quick.

Heading back into the special 400-foot AGL pattern used for LSAs, we used a 65-knot approach because of the wind and gustiness. Turning final for the runway (usually a taxiway), we slowed to 45 knots on short final with full flaps (40°).

Gobosh President Tim Baldwin (right) and Aero President Tomasz Antoniewski, the manufacturer, get together in the air.

Touchdown was soft. The Gobosh G700S handles exceptionally well, even in less than ideal conditions.

A lasting impression is that the G700 has considerably heavier controls than many LSAs and therefore feels more like flying a GA airplane, which may help some pilots feel comfortable. But wing loading is less, so the experienced pilot needs to pay more than the usual attention to wind and get more than a cursory checkout in ideal conditions.

Other Considerations

LSA dealers and aviation insurance companies have noted a disturbing trend: High-time general aviation pilots without experience in low-wing-loading airplanes such as LSAs have high accident rates early in their LSA flying experience. That fact combined with lack of parts for repairs of some LSAs—particularly the imported ones—has resulted in high insurance costs. As noted recently in this column, Avemco has mandated a minimum of 5 hours of transition training for every LSA buyer regardless of previous experience.

Like some other importers, Gobosh has attacked the problem from two directions. First, the price of its aircraft includes transition training. Second, the company stocks parts so that repairs and maintenance can be completed in a reasonable time.

At some point, we expect to sample Gobosh's composite G800XP, which Settember says flies quite differently. I look forward to that.

For more information on both aircraft, visit www.gobosh.aero. You can find a direct link at www.kitplanes.com.

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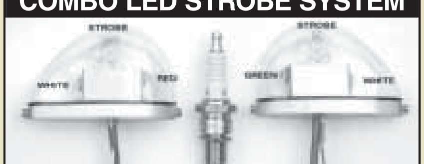

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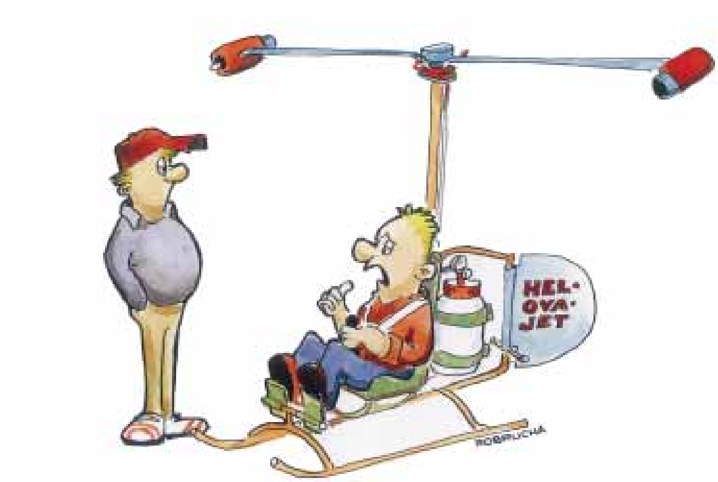

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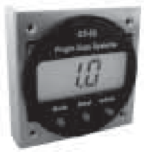

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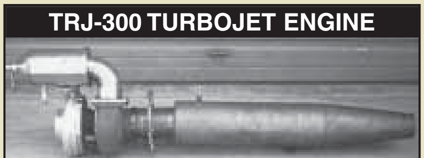

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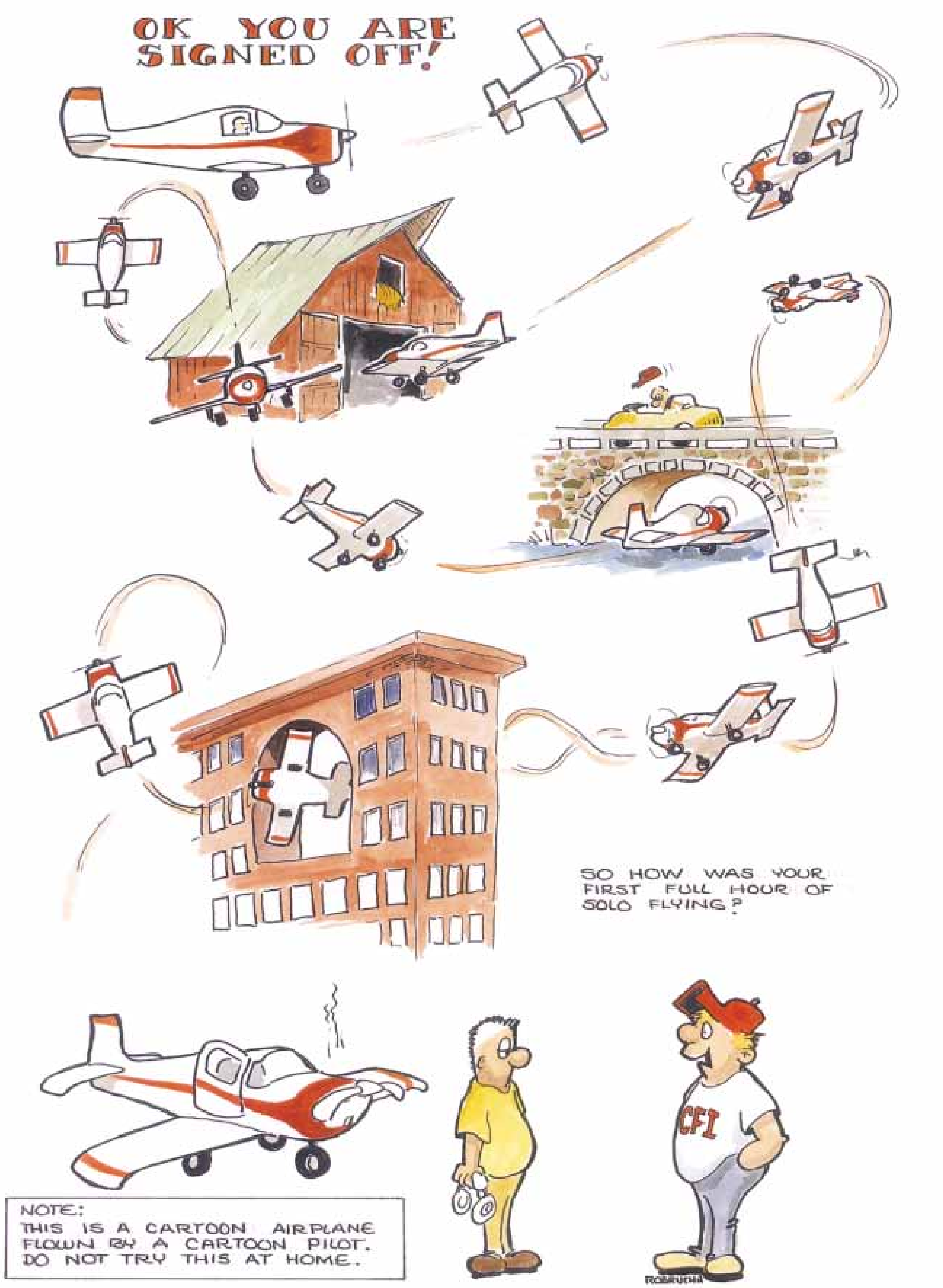
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