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AROUND the Patch

BY MARC COOK

You've got engine options galore!

This year, like last year, I'm delighted to see our engine directory come together, if for no other reason than the fact that it reminds me that builders have some amazing options in powerplants. For the 2005 installment of the engine directory, I was spurred to connect with my old friend Larry Simpson, who was meticulously working through the installation of an Eggenfellner Subaru into his RV-7A. I had a chance to see that airplane last October while I was in Florida, and I have to say I'm impressed. Moreover, Larry is on schedule to fly early in 2006; in fact, he could well have been airborne by the time you read this.

Nevertheless, in rambling through the '06 engine directory, I'm reminded that the alternative-engine crowd is hanging in there just fine while the meat of the market continues to be in conventional aircraft engines. (Two alternative engines I'm watching closely, the Innodyne turbine and the Delta Hawk V-4 heavy-fuel engine, are high on my list to fly this year. Actually, there's a third: The Mistral rotary. Hmmm. Not enough hours in a day to fly everything I want, probably.)

But by no means does the fact that the center of gravity in kit aircraft engines revolves around familiar designs take away from the innovation side of the equation. Despite very little marketing on Lycoming's part, the firm's kit engine program seems to be gently lifting off the runway. Engine shops that used to have to scrounge for parts to build certain engines can now get all-new components in kit form. As we reported last year, the program gives builders some significant options on the accessory side but little latitude on the major engine components. You can't, for example, spec a Lycoming kit engine with ECI or Superior cylinders. However, the engine shop is free to do its own minor modifications, such as cleaning up of the ports or balancing rotating and reciprocating components. If you order one of these, be sure to keep track of what is and is not included in the engine. Some builders are finding that some hoses, fuel-system components and other seemingly minor accessories normally provided with factory-new engines are not in the kit engine box.

It's great to see the aftermarket settling into a sustainable routine, able to offer engines with a traditional footprint in everything from near-stock to heavily breathed-upon configurations. When there's this kind of competition, consumers benefit with better products and/or lower prices. Case in point: The Lycoming IO-390-X engine, at press time, was still thousands less as a kit than the otherwise similar angle-valve IO-360. Clearly, Lycoming wanted to push the new engine and so priced it attractively, but who can argue with getting a more recent iteration—I hesitate to call it a new design, as the principal change from the 360 is the bore diameter—for less money?

Speaking of money, here's an entry from the What Are They Thinking? Department: Rotax suffers from the old exchange-rate blues there's no doubt, but to price the 912 S at $24,000 seems just a little bit insane. On a horsepower-per-dollar basis, that's a tough one to swallow. Now I appreciate why some of the Light Sport Aircraft manufacturers have been wiping brows and complaining about the costs of doing business when the engine is such a big part of the cost of the airplane. We really need a truly affordable 80- to 100-hp engine to make the LSAs perform well and be economically viable. Maybe Honda could dust off some old Gold Wing design studies and give us an alternative. Stranger things have happened, you know. One thing's for sure: A large segment of the potential LSA market would respond favorably (or not adversely) to an alternative engine manufacturer.

Program Note

The second part of our in-flight hazards avoidance story will not appear this issue as promised. It *will* arrive next month, bigger and meaner and brimming with good advice to help you pick the best technology for your needs. No, really...

How Much Was That?

I received a pleasant email from Budd Davisson, lead man at AviPro, who pointed out an error in our Bearhawk review. We listed the base price as excluding quickbuild options, as is the norm. However, he says, "We don't have a non-quickbuild in the traditional manner. You can buy the QB fuselage or QB wings separately, the fuselage as just the tubing cage all welded with the fittings in place or a rib/spar package. We offer an array of steel parts to support the scratch builders. Inasmuch as there are over 900 sets of plans out there, we're doing our best to support those builders too. I'm not sure, but I think the BH may be the only four-place that can be either kit or plans-built." So in this sense, the Bearhawk has paws in two distinct camps: Quickbuild or semi-scratch build. Or, for that matter, several points in between. Regardless, at $29,750 in full quickbuild form—all that's optional at that price are the auxiliary fuel tanks—it has to rate as a pretty good deal in a four-place utility aircraft. ✈

Marc Cook has been in aviation journalism for 19 years and in magazine work for 25. He is a 3800-hour instrument-rated, multi-engine pilot with experience in nearly 150 types. What's more, he's mad about homebuilts.

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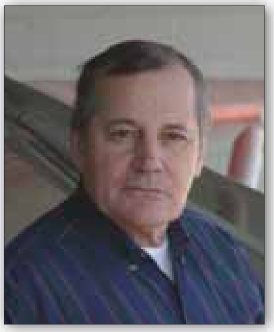

LEROY COOK

Here's a name that's surely familiar to long-time readers: LeRoy Cook, author of "Fighter Pilot Fun..." on Page 12, is truly a KITPLANES® original, having been published in our first ever issue in 1984. Cook has been flying and instructing for more than four decades and calls himself a lifelong student of aviation. "Homebuilts continue to be a passion," he says, "because they answer every pilot's yearning to express himself by flying something unique. The Loehle replicas certainly answer that desire."

JULIA DOWNIE

Wow, two in one issue—Julia Downie's name also graced the pages of that very first issue as author of our "1984 Guide to Kit Airplanes." "I've always been detail oriented," Downie says, " and when [original KP editor] Dennis Shattuck said we needed a directory, I got out an accounting spreadsheet and started filling in cells. The part I've most enjoyed is contact with the companies—aviation people are great!" Downie's been at it ever since, having compiled our annual buyer's guides for more than 20 years.

CORY EMBERSON

Cory Emberson conceived the idea for her piece on the dedication of *SpaceShipOne* (Page 41) after stumbling upon the Smithsonian's booth last summer at Oshkosh. The visit to Washington to witness its public unveiling and research the back story of the historic aircraft's move to the museum proved a memorable experience: "Burt Rutan was watching the video retrospective at the dedication as if he were a kid looking at Disneyland for the first time—a true look of wonder. I think the real thrill of everything that Scaled had accomplished began to hit him then."

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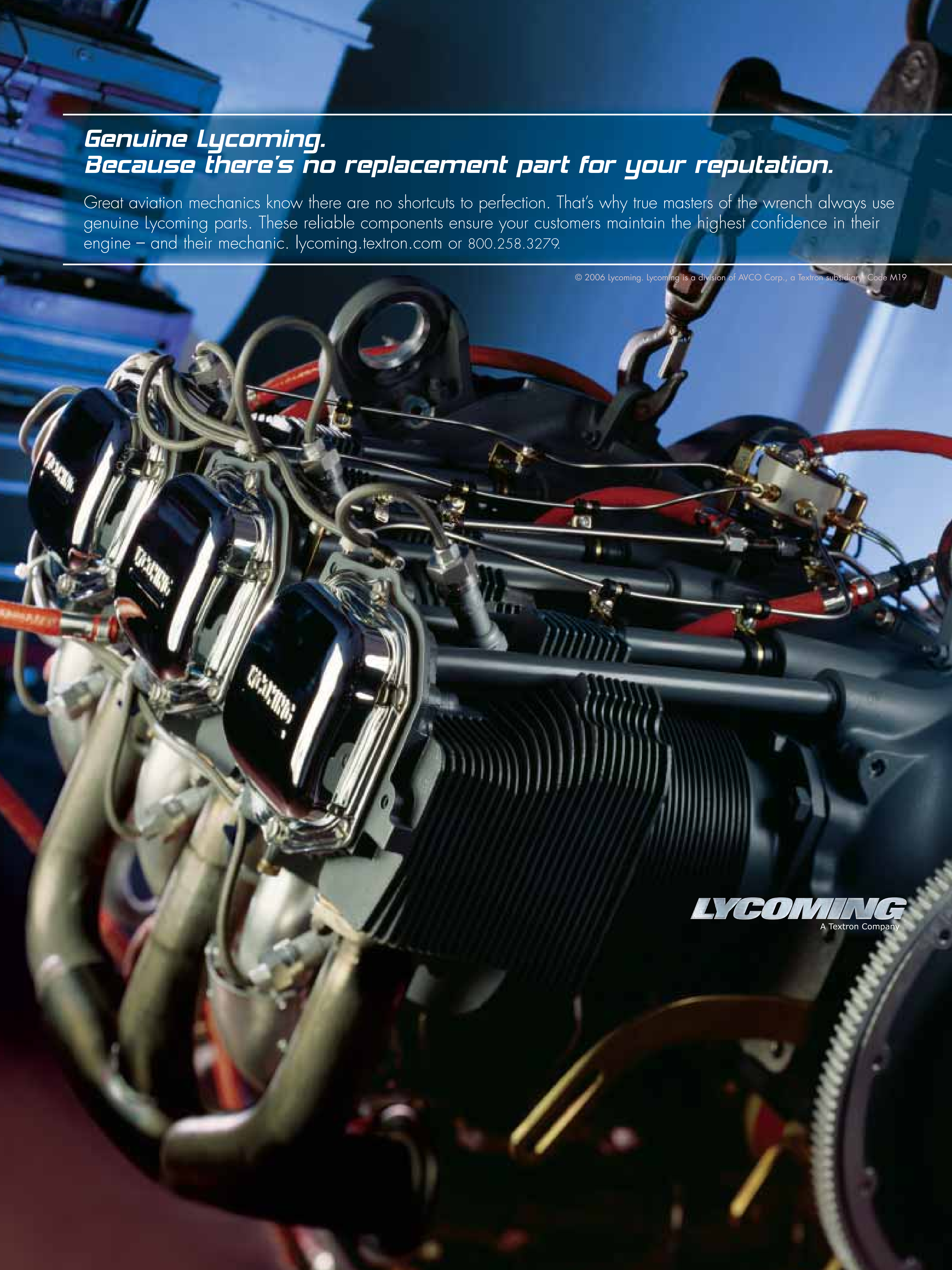
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LETTERS

EDITORIAL@KITPLANES.COM

Good Handling, Defined

I am an aeronautical engineer and engineering test pilot (U.S. Naval Test Pilot School). My experience level covers a rather broad swath of the flying game, both military and general aviation (it's important for a test pilot to have this type of exposure to many different types so that he has perspective on what's possible and what isn't). I don't often write letters to the editor, but your comments on handling qualities [in the December 2005 "Around the Patch"] caught my attention.

Congratulations on the decision to write this piece. The subject of the adequacy of general aviation aircraft handling qualities does not get the exposure that it so richly deserves. This has been the case for many years. Instead, as you know, emphasis is placed on performance (a quantitative, measurable number), creature comforts and the number of gadgets the airplane contains. In retrospect, this is understandable; these things are tangible.

On the other hand, with respect to *how* the airplane flies, there is a distinct tendency, on the part of the consumer pilot, to take the view that "Well, this is how God intended this airplane to fly; therefore, if I have problems making decent landings, the fault must be mine." Nothing, of course, could be further from the truth. Adequate handling qualities are (or should be) a prime design goal, right up there with structural considerations and performance and, if the design and flight test teams have done their jobs correctly, then the consumer pilot (still believing that God had something to do with it) lands his airplane with a big smile on his face.

In the flight-test business, there are two basic categories of evaluation—quantitative and qualitative. Performance evaluation is a purely quantitative exercise, while handling qualities evaluation (much more complex) is both quantitative and qualitative. When test pilots evaluate aircraft handling qualities, they use a scale called the Cooper Harper Rating Scale to measure the adequacy of the handling qualities. The scale is both numerical (quantitative) and textual (qualitative). The purpose of the textual scale is to give meaning to the assigned numbers. On this scale, a rating of 1 is the perfect airplane (I have never given any airplane a 1). A rating of 10 is an uncontrollable airplane. Ratings between 1 and 10 reflect the relative "goodness" of the handling qualities when measured *against a defined mission* (very important—you do not evaluate a 747 as an acrobatic airplane).

Historical data show that when a group of qualified (also very important) test pilots are asked to evaluate the handling qualities of a specific aircraft *against a defined mission*, the variation in the Cooper Harper Rating from one test pilot to the next is rarely more than a dispersal of 1. I point this out because in your editorial, you observed that "Good handling is, I confess, a subjective matter—at least to some degree." This view implies that a particular set of handling qualities, say, a 4 on the test pilot's Cooper Harper Scale, could be accorded anywhere from a 1 to, say, a 7 by the average consumer pilot. Not so. If the test pilot has done his job correctly and gives the airplane a 3, it is very likely that the consumer pilot would also give the airplane an (equivalent) 3, plus or minus 1.

Developing adequate aircraft handling qualities is a complex discipline. As you point out, the process begins in the design stage. The aircraft designer is assumed to know the difference between good handling qualities and bad handling qualities. If he does not, then problems begin in the design stage. The process continues in the flight test stage. The test team is assumed to know the difference between good handling qualities and bad handling qualities. If they do not, then problems continue in the flight test stage, and the aircraft is likely to reach the market with undesirable handling. Again, as you point out, excellent handling does not come easily and considerable effort, time and money can be required to iron out the bugs (assuming that they are recognized). The reason is that the very complex inter-related factors that determine the adequacy of the handling qualities result can not be completely analyzed prior to flight test.

At the end of the day, a company test pilot will be called upon to render a quantitative/qualitative evaluation to determine whether all the complex factors, working together, have resulted in a 2 or a 5. If he knows what he's doing, a 5 will not get to the consumer pilot.

There seems to be a misperception about the connection between speed and the difficulty involved in flying "high performance" airplanes. Fast airplanes are considered to be "hot" and inherently more difficult to handle. This misperception is so far from the truth as to be (kinda) funny.

Overall, the best handling airplane that I have ever flown was the F-86 Sabre. I gave the airplane a 1.5 on the C-H scale, for the fighter mission. The airplane is a piece of cake because North American got the handling right and any reasonably competent general-aviation pilot would have no problem flying the thing. Ditto the Cessna Citation. On the other hand, I've flown a couple of the current fast glass, "high performance" airplanes at one third the speed of the F-86 and they were not a piece of cake, they were very difficult. Somebody did *not* get the handling right. Probably the most difficult airplane I've ever been in was the Helio Courier at one sixth the speed of the Sabre.

It was not my intention to write a handling qualities treatise, but the subject matter, in my view, is so important as to warrant the effort. Every airplane delivered to John Q. Public ought to be "a piece of cake."

MIKE ANTONIOU

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WHAT'S NEW

FAA Approves Dream's Fastbuild Tundra Kit

Dream Aircraft, manufacturer of the Tundra kit aircraft, announced that the FAA has approved its recently developed fastbuild kit as legal per the regs of the major portion rule. According to Luc Prémont of Dream, the company has completed as much work as possible on the kit while ensuring it still adheres to the 51% rule.

The wings come nearly complete; the builder needs to install just one of the skins to close them. And it works the same for empennage and fuselage. Nearly all of the internal brackets and fittings come installed.

Dream estimates that it will take a builder about 300 hours to put the rest of the Tundra kit together, not including engine installation or instrument panel. Compare that to the 1000-hour estimate for the standard kit.

Introduced in 2003, the Tundra is a high-wing, four-place utility airplane with a useful load of more than 1100 pounds. The all-metal plane can be built as a taildragger or trigear, and can be fitted with floats or skis.

Purchase of a fastbuild kit adds $18,705 to the base kit price of $33-$36K, depending on gear choice. For more information, contact Dream at 450/372-9929 (ext. 28). A direct link to the company's web site can be found at www.kitplanes.com.

MilSpec Cowling Fasteners Available Directly to Public

MilSpec Products of Sorrento, Florida, announced that due to increased demand and a desire to work more closely with kit manufacturers and the end users of its products, the company will be offering its quarter-turn cowling fasteners directly to the public. MilSpec is the original manufacturer of TSO C-148 certified fasteners for the general aviation market and has been a consistent leader in quick release fastening systems.

"We are focusing more on the kit airplane market because we feel that general aviation will continue to move in the direction of favoring more streamlined, smaller production companies and individual builders in the coming years," said Jeremy Summers, MilSpec president. "We will continue to work closely with our existing dealers in addition to stocking ready-to-ship inventory at the plant, which will be designated for direct-to-consumer sales."

MilSpec offers various model-specific cowling fastener kits as well as individual fasteners, bulk packages and installation tools. Its kit listings include options for the Van's RV series and Lancair models in addition to many common certified designs. The company also expanded its manufacturing capabilities in the last quarter of 2005 to nearly double its previous production rates.

For information on the fasteners, kits or technical questions, contact MilSpec at 352/735-0065. A direct link to the company's web site can be found at www.kitplanes.com.

New KitLog Pro Adds Features, Online Hub for Builders

Aeroware Enterprises announced the release of the latest edition of KitLog Pro, v2.0. The program is a software-based organizational tool that allows an aircraft builder to create, archive, manage and display the entire construction process. The long anticipated release includes an entirely new look, added features, functions and flexibility and the ability to post construction logs to the internet.

Some of the basic features include the following: ability to create and maintain a detailed construction log highlighting individual tasks; an expense log sorted by user-defined categories; storage and organization of digital photographs; and the ability to print the log into a well-organized format to be used for FAA paperwork submission. KitLog Pro runs on Microsoft Windows 2000 or XP operating systems.

Also released is My KitLog, an online builder hub where registered KitLog Pro users can post their projects on the internet, free of charge. The My KitLog section of the company's web site includes builders from around the world showcasing their latest projects, which can be searched by name, aircraft type or location.

To date, the company says more than 2500 copies of KitLog Pro have been sold. KitLog Pro v2.0 costs $49.95 and a 15-day free trial is available. For more information or to purchase a copy, visit the company's web site—a direct link can be found at www.kitplanes.com. For additional questions, call 480/361-9011.

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With the kind of *performance* you get from the Legacy you'll also want avionics that *perform*. Meet the Chelton EFIS SV-Sport. A dual-screen Synthetic Vision EFIS system that gives you Highway-In-The-Sky navigation (HITS), an integrated GPS and Flight Managment System, with terrain mapping and obstruction avoidance—all driven by Level A FAA certified software. While other EFIS companies are promising, Chelton is delivering. Add to that the complete dedicated support from Direct To Avionics and you get an incredible value no other can offer.

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Barracuda Subkits Available from Aircraft Spruce

Siers Flight Systems, distributor of plans for the two-place, wood Barracuda design, announced the availability of eight new materials kits through Aircraft Spruce. These are the first subkits available for the design and promise to drastically reduce building time.

Four kits comprise the basic airframe structure: plywood, wings, spars and body. They range in price from $700 to $2300 and cost a total of $5600. Additionally, there are two metal kits, one for welded parts ($708) and one for non-welded parts ($693), an electrical kit ($818) and a fastener/hardware package ($2289). Each kit is designed to be purchased sequentially in conjunction with the plans. The smaller units allow builders on a budget to buy the materials when time, space and money permit.

The company estimates the remaining items required (including engine, prop, instruments, landing gear and paint) at approximately $38,000. A well equipped Barracuda can be assembled for less than $50,000, Siers says. And custom landing gear and spinners are available via Siers Flight Systems.

British fighter pilot Geoff Siers designed the aircraft in the 1970s but sold the rights to Buethe Enterprises in 1983. Richard Siers, Geoff's son, reacquired the rights in 2003 and offers a set of 31 professionally drawn blueprints and a builder manual for $300.

For more information on the Barracuda, call 425/478-3655. Or, call Aircraft Spruce to order kits at 877/4-SPRUCE. Direct links to each company's web site are available at www.kitplanes.com.

Pi Tape: Precisions Measurement on a Budget

For more than 60 years, those working in the aerospace and automotive industries have relied on a simple, easy-to-use instrument that allows them to measure the true diameters of round and out-of-round forms quickly and precisely. In an age when fancy, high-tech products are all the rage, Pi Tape is decidedly low-tech and uncomplicated, yet accurate and cost effective.

Pi Tape gauges are available in either inches or millimeters. Standard tapes are engraved and acid-etched on a ground surface and feature a fixed reading that does not require periodic adjustment. In terms of speed, the manufacturer says that Pi Tape is much faster to use than micrometers, calipers or laser-type devices, each of which require the user to take multiple readings and average them to determine diameter. With Pi Tape, simply wrap the gauge around the inside or outside of a form and get a diameter reading accurate to .001 inch.

The Pi Tape product line includes direct outside and inside diameter measuring tapes, linear tapes and O-ring tapes. There are two easy-to-read styles available for low-light environments and stainless steel tapes for use in corrosive environments. Pi Tape also offers recalibration services for all its measurement products.

Pi Tape products are available directly through the company's sales department or through a variety of distributors. There are a number of sizes and styles, so prices vary. Basic types start at around $60 and more advanced styles and sizes range to the $200s. Contact the company at 866/474-8273. A direct link to the company's web site can be found at www.kitplanes.com.

Larger Air Command Fuel Tank Increases Range

Air Command International, manufacturer of the Elite and Commander series of kit and ultralight gyroplanes, announced the availability of a new 10-gallon plastic seat tank for its aircraft. The unit incorporates the fuel tank and the seat into a single entity and will improve range on any of the company's designs.

"With the larger engines burning more fuel, we saw the need for a larger capacity seat tank," said Doug Smith, operations manager for Air Command. "The new 10-gallon seat tank can replace our standard 5-gallon seat tanks using the same seat attachment parts."

The 110-hp Hirth F-30 is one example of the larger engines Air Command pilots are using. The new tank, colored black, is 17.25 inches wide, 19 inches deep and 27 inches tall. The standard 1-inch-diameter U-shape aluminum tubing attaches the seat to the gyroplane's fuselage, Smith said.

And though upgrading to the new fuel tank is a simple job (especially for anyone who built their gyroplane), the full tank in its new configuration will change the gyro's center of gravity. "I urge users of the new tank to do a hang test and to make appropriate adjustments before attempting to fly with it," Smith said. Sounds like good advice.

Suggested retail price for the new unit is $625. For more information, contact Air Command at 903/527-3335. A direct link to the company's web site can be found at www.kitplanes.com. +

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Fighter Pilot Fun, Minus the Fuss

Mike Loehle conceived the idea for the 5151 Mustang kit after purchasing a snap-together P-51 model at a highway rest stop on the way home from Sun 'n Fun one year. Believe it or not, the 5151 designation actually indicates the kit's original price—$5151—*with an engine*!

Easy to fly, easy to build and easy on your wallet, Loehle's 5151 and P-40 kits have been bestsellers for years.

BY LEROY COOK

Breathes there a man with soul so dead, who never to himself hath said (upon viewing a classic warbird), "I wonder what it would be like to fly *that*?" But then the harsh reality of life casts a pall over the scene, and he realizes that it takes years of progressive training and a millionaire's toy box budget to earn pilot seat duties in a P-51 Mustang or P-40 Warhawk. Unless, of course, that man is a champion of the Experimental/Amateur-Built cause!

Mike and Sandy Loehle run the successful kit company with the help of sons John (far left) and Matthew (who wasn't available at photo time).

It was exactly this yearning that Mike Loehle sought to satisfy when he introduced his 5151 Mustang kit 20 years ago. Loehle was into the powered ultralight scene in a major way, selling his Aeroplane XP biplane and various other ultralight designs for which he was a dealer. Just a year before, he and business partner Sandy Burgess had bought the former Ritz Propeller factory and were using it to build their business in a Tennessee mountain valley near the aerospace hub of Tullahoma. To them, it was obvious that the ultralight industry needed a shot in the arm to move it into the grown-up age of little airplanes.

From Ultralights to Fighter Planes

As Sandy tells it, Mike bought a snap-together P-51 model at a highway rest stop while they were trailering home from Sun 'n Fun, and he ogled it all the way back to Tennessee. *That*, he determined, was just what they needed—a replica fighter in stand-off scale size that the everyday pilot could buy, build and fly. Carl Loehle, Mike's dad and Loehle Aircraft's chief designer, buckled down and generated a design for an approximately three-quarter-scale P-51, the bare framework of which was displayed at Oshkosh 1985. The rest, as they say, is history.

Just 11 months after the idea was hatched, the Loehle 5151 flew right off the drawing board. The company coined the 5151 designation because the kit could be built per the regs of the 51% rule and because it was priced at $5151, including the Rotax 503 engine! Inflation quickly abrogated that price, but it wouldn't have lasted long in any event— product enhancements arrived quickly in response to customer demand. A few modifications later, the engine became the huskier liquid-cooled Rotax 582, and Loehle introduced retractable landing gear in 1990. After all, what kind of WW-II fighter plane would fly with its wheels down?

The 5151 sold like gangbusters (450 kits to date), and the company began development of a similar P-40 "Flying Tiger" kit in due course, using most of the Mustang's wood structure with different stringers to alter the shape. As Loehle tells it, the P-40's birth was somewhat unplanned. Loehle and Sandy (by then Mrs. Mike Loehle) planned to offer a low-cost ($2500 complete) Loehle Sport Parasol as their new-for-1990 aircraft because the state of the national economy seemed to require an entry-level kit airplane. The Sport Parasol was a gentle-flying cross between a Pietenpol and a Heath, able to qualify as an ultralight at 253 pounds with the diminutive Rotax 277. The Parasol remains a staple in the Loehle line, but the P-40 fuselage displayed in the 1990 Oshkosh booth stole the show. Customers lined up to place orders, and immediate demand forced Loehle Aircraft to start selling its new fighter replica a year or so earlier than planned.

But the P-40 wasn't destined to be the last word in Loehle fighter replicas. Jim Young of Gainesboro, Tennessee, is a capable machinist and kit builder, and he wanted to be the bad guy on the block by turning his 5151 kit into a German fighter. With a revised cowling, canopy and turtledeck (all now available from Loehle), Young created a plane called the KW-909, a mix of Kurt Tank's Focke-Wulf 190 and Willy Messerschmitt's Me-109. Its sinister shape offered the perfect complement to the American fighters.

More fighters followed, albeit ones that differed significantly from the 5151 and P-40. Loehle Aircraft offers gusseted aluminum tubing kits for WW-I biplanes, buildable as either ultralight or Experimental aircraft. The preassembled airframes can be finished as a Spad XIII, Fokker D-VII or British SE5A.

My mission, however, offered the chance to sample the Mustang and Flying Tiger single seaters, long the company's most popular designs. I headed for Tullahoma and met the Mustang first.

Making a Mustang Look-Alike

Loehle likes wood, a time-proven medium that's comfortable for most first-time builders and tolerant of the mistakes they're bound to make. Accordingly, his WW-II replica fighter line uses an all-wood structure except for fiberglass fairings, cowling and spinner. The fuselage is a basic de Havilland box, no more complicated than a big model airplane, with gusseted bulkhead rings covered by sheets of plywood back to the rear of the cockpit. From there, wood longerons are braced with geodetic basket-weave-arranged strips to create a strong aft fuselage.

The empennage is similarly of wood construction, and the wings use a 12-inch-deep box spar, attaching just outboard of the landing gear. The 1.7-ounce fabric is glued in place; no rib stitching is required. The center section carries the gear's mounting and optional wing fuel tanks, 4 gallons per side, allowing the aircraft to be trailered with the outer wings and 11-foot-wide horizontal tail removed. Plywood leading edges and

Following the huge success of the Mustang 5151, Loehle Aircraft began work on a P-40 fuselage. The in-progress fuselage that Loehle displayed in its Oshkosh booth caused such excitement that Loehle sped up its efforts and debuted the kit shortly after.

Both the Mustang and Flying Tiger feature the Rotax 582 as standard, and it's visible here tucked neatly beneath the cowling of the P-40 (left). Builder Glen Holder, who volunteered his Mustang 5151 for our flights, opted for a Walter Mikron four-cylinder inverted inline engine from the Czech Republic (right).

Photos: LeRoy Cook

Loehle's kit version is approximately 75% scale compared to a military P-51. It's all wood except for fiberglass fairings, cowling and spinner.

geodetic strips outboard give the wing its stiffness, and the precut ribs are engineered to provide 2° of washout at the wingtip.

To create the Mustang look-alike, Loehle added stringers and formers to the upper fuselage and replicated the famous P-51D's bubble canopy and Merlin-housing cowl. Early 5151 kits had fabric and stringers forward of the windshield, but the latest option uses a composite upper and lower cowling for shaping. The Mustang-style radiator scoop under the cockpit is non-functional—aside from sex appeal, of course—and the lower cowling hides the Rotax 582's muffler and radiator. An aluminum-covered firewall is used, and the upper cowling shell features joggled-fit panels to cover a ballistic parachute bay, a small storage compartment and access to the 5-gallon nose fuel tank.

Gearing Up

The landing gear is a marvel of simplicity. The tires constitute the airplane's shock-absorption system because the gear legs do not incorporate shock struts. The solid-doughnut tailwheel is steerable and swiveling. Before jumping into the single seater, I practiced gear retraction a few times with the P-40 on jacks (a highly recommended practice) and found it easy to perform. There's a locking latch for reassurance, though Loehle calls it unnecessary since the linkage goes over center, and once the latch is released, a crank on the left side of the cockpit requires 21 turns for retraction. This requires no more effort than raising a window on your pickup truck, thanks to the assist springs. Mechanical indicators protrude from each wing's leading edge when the wheels are down.

And what happens if you forget to put the gear back down? Though Loehle says "there's never been a failure of an unmodified gear system," a few gear-ups have been, uh, performed. Fortunately, the slow touchdown speed makes for little damage: the tailwheel rolls normally, the fake radiator scoop crushes as it was designed to do, some paint gets scraped away and a new propeller is required. Could be worse, for sure.

Meeting My Mustang

Eager to fly the 5151, I turned to Glen Holder, a Tullahoma-based builder with several modifications on his ship, who had volunteered his airplane. Holder powers his 5151 with a four-stroke, air-cooled Walter Mikron four-cylinder inverted inline engine built in the Czech Republic. It produces a nominal 65 hp and thanks to a magnesium block weighs 155 pounds dry.

While the P-40's basic structure is the same as the Mustang's, differences include the pudgy lower cowling, lack of a belly scoop and the characteristic razorback rear fuselage with quarter windows.

In addition to the engine, Holder installed large wing flaps for cosmetic reasons; it may look more like a P-51 parked with the flaps down, but Loehle is correct in insisting that the last thing these light planes need is more drag. In other words, he thinks the flaps should *not* be used in flight. Holder's ailerons were mass and aerodynamically balanced for a lighter feel and flutter prevention, not something Loehle recommends because his little replicas are not aerobatic in any way. VNE is set at 100 mph, a limitation easily exceeded in extreme maneuvers, and Loehle prefers to have control feel stiffen with increasing speed to prevent overstress.

To achieve an accurate replica of the original P-40 Warhawk, Loehle altered the shape of the Mustang's wing and tail.

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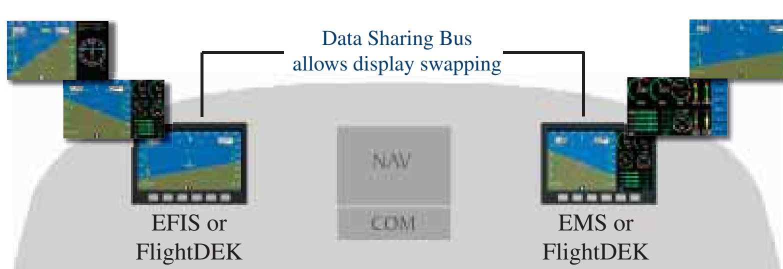

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Before flying the two retractable-gear fighters, the author practiced gear retraction with the P-40 on jacks.

Holder demonstrated how to step onto the wing ahead of the flaps and then swing both feet into the seat to reach the cockpit. The canopy frame is non-structural aluminum tubing, so for entry, you hold onto the upper longerons and ease down while stretching forward to the rudder pedals. There's plenty of space in the expansive nose for long-legged builders to customize their stretch-out room. And the 24-inch-wide cockpit is ample for most folks. Holder's flap handle is in a less-than-optimum right sidewall location; if it were to be used extensively in flight, it would be handier on the left side. Holder uses a Garmin GNC 250XL GPS/comm and a GTX 320 transponder under the dash; the control stick grip featured an electric trim switch along with a push-to-talk guns trigger.

Here's the cockpit of the single-seat P-40; the red T-handle at the right is the firing pin for the BRS parachute, the handle on the stick is for brakes, and the crank and bicycle chain on the left sidewall is for gear actuation.

The Walter engine requires neither carburetor heat nor mixture control. Mags on, I flipped on the master and pulled the starter handle to gain instant ignition. The Walter settled into a 1000-rpm idle, and I was grateful for the responsive individual heel brakes as I taxied away. Moving toward the runway, the long nose required an occasional fighter pilot S-turn—I liked this already! The four-blade propeller had a nice sound added to the four inline exhaust stacks in the nose.

Taking Her Up

The 5151 required no special attention to hold the tail down for steering or runup, and with the control stick stirred, mags checked at 1500 rpm, altimeter set and the canopy slid forward and latched, I was ready to go. Holder cautioned in advance that his airplane was not overly endowed with climb performance (he's considering a 75- or 80-hp version of the Walter), but I found that the Mustang accelerated rapidly for takeoff even though it's 200 pounds heavier than most Rotax-powered 5151s. The wheels came off at 55-60 mph in some 1000 feet of runway. At 73 mph, the climb rate was timed at about 250 fpm, gear down. With gear up, the rate was nearer 350 fpm.

In flight, the 5151 certainly captures the flavor of a Mustang cockpit (although it's a lot quieter), and I flew Holder's silky ailerons with two fingers on the stick. The Walter requires left rudder for torque correction during takeoff and climb, as does the Rotax, but if you give the aircraft what it needs to maintain its heading, you won't notice it. Leveled at 1500 feet AGL, I let the Walter wind up to its full 2600 rpm and saw an 85-mph result. Cruising at 2500 rpm provided 80 mph indicated—right in line with Loehle's predictions of 75 to 85 mph—and I flicked through some lazy eights and chandelles just to enjoy the little mini-fighter, mindful not to be tempted to

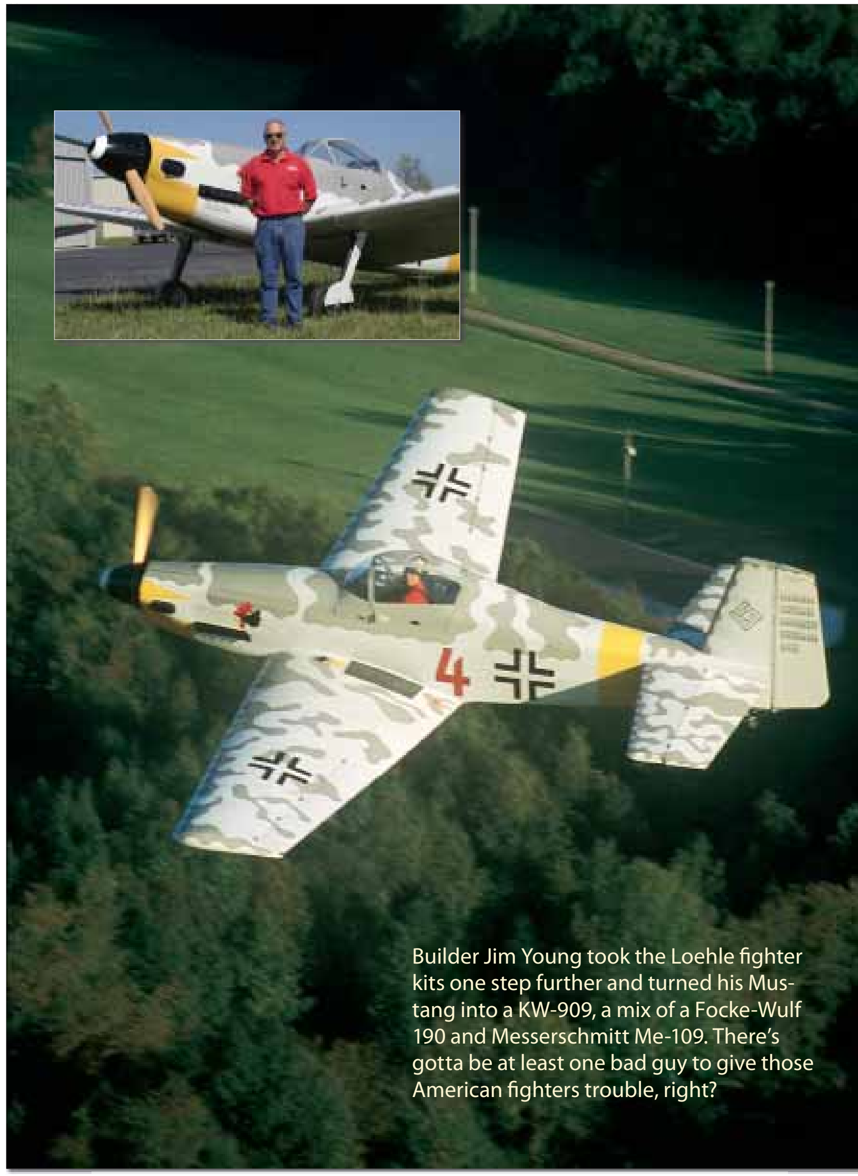
Geodetic basket-weave-arranged bracing strips provide much of the strength in the all-wood Mustang airframe.

On an in-progress kit, the innards of the gear retraction system are visible. Both the Mustang and P-40 use the same system; a crank in the cockpit requires 21 turns for retraction.

exceed normal attitudes. Control harmony was good, and I noted little adverse yaw from the ailerons.

Slowed down for a stall, I idled back and eased the nose up to find a break at 53 mph IAS. The Walter has to think a bit about accepting throttle from an idle, but it goes back to work in a half-second with no problem. The stall was well advertised and easily recovered in 100 feet or less. Although it wasn't recommended, I took advantage of the altitude to perform a gently approached full-flap stall, finding no unusual tendencies except perhaps a little more burbling at the 48-mph break and more time needed to clean up and start a climb.

And even though those flaps offer four settings, Holder recommended no more than one notch for the landing approach—I came in at 70 mph on my first attempt. Visibility on approach was quite good (four deer crossed the runway on their evening browse, but there was adequate space beyond them), and due to the airplane's relatively large size and low weight, it settled into a touchdown shortly after the power was cut. Wheel landings are preferred to avoid dropping in on the stiff gear and for better visibility. The 5151 tracked true on rollout, no more demanding than a Champ or Cub, the airplanes Loehle used as the criteria for his designs.



Builder Jim Young took the Loehle fighter kits one step further and turned his Mustang into a KW-909, a mix of a Focke-Wulf 190 and Messerschmitt Me-109. There's gotta be at least one bad guy to give those American fighters trouble, right?

The Flying Tiger Layout

After thanking Holder profusely, I returned the next morning for a dawn patrol mission in the P-40. Loehle apologized for the 12-year-old airplane's looks, reminding me that it was only a prototype. I thought it was in great shape with its Nationalist Chinese markings.

The Flying Tiger differs from the 5151 in the pudgy shape of its lower cowling, the characteristic razorback rear fuselage with quarter windows and the lack of a belly scoop. Unlike the 5151, the P-40's canopy blows aft if left unlatched, Loehle says, while the bubble canopy of the Mustang sucks forward.

The shape of the wing and tail are different, of course, and the gear axles are reversed, although the P-40 replica uses the same gear system, swinging inboard instead of swiveling aft like the Curtiss airplanes. The cockpit was bereft of avionics, but we did have a replica optical gun sight. Loehle's prototype electric trim switch is on the floor under the left leg, but because there's not a lot of trim changing required, its remote location is not a big deal. No trim indicator was provided, so I looked outside at the left elevator to check alignment.

The cockpit layout is simple VFR with water, cylinder head and exhaust gas temperature readouts for the 582's twin cylinders. The dual ignition and starter is controlled by a rotary key switch, and the fuel selector resides under the pilot's right knee.

Piloting the P-40

The warm Rotax fired immediately, and I eased away from the ramp with the same sinuous movements used in the 5151. The P-40's mechanical brakes are simultaneously actuated by squeezing a bicycle lever on the stick, a simple but effective system. The two-stroke engine was warmed and ready at the end of the runway, the controls were stirred and the canopy was locked, so I was ready to go repel some invaders.

The willing little 582 had plenty of muscle to pull the mini P-40 down the runway toward a 55-mph liftoff in a few hundred feet, and I climbed out at 63 mph while the engine hummed away at 6200 rpm. The climb rate computed to 800 fpm, quickly hauling me up to 2000 feet AGL. Leaving the pattern, I flipped the gear lock off and dialed in 21 turns of the crank, neatly folding the wheels for battle.

Leveling off, I found the P-40 to have an ultralight-like wall retarding speed buildup. At 5800 rpm, I saw 70 mph IAS, which Loehle says equates to around 80 mph of calibrated speed. (The P-40's performance in our photo shoot confirmed his assessment.) No amount of power would make the relatively large, lightweight replica go much faster. But the fighter pilot experience is what I was after, and 80 mph is enough to go places anyway. The stock unbalanced ailerons were heavier than those of Holder's 5151, and, as Loehle intended, the P-40 flew similarly to a Cub or Champ, requiring some rudder input to enter and coordinate the turn. Slowed down for a stall, I encountered a power-off break at 47 mph IAS.

Regretfully, I flew back to the field having spotted no bogies in the area and extended the wheels with a few seconds of cranking. My 60-mph landing approach was easy to place on an aiming spot thanks to the P-40's abundant drag, and I wobbled into a semi-stalled touchdown at 50-55 mph. Not satisfied, I poured on the power for a stop-and-go instead of taxiing to the revetments. For the next try, I held a tad more power and landed on the backside of the wheels for an easy tail-high rollout. Now I could return to face my crew chief!

Want to Build One?

On my subsequent tour of the factory and parts warehouse, that wonderful scent of fresh-cut wood and sawdust greeted me. Several kits were boxed for shipment. "About 20% of the production is exported," Sandy Loehle says, the rest completed in house. And these kits are not just lengths of wood and sheets of plywood—the parts are precut and numbered including die-cut plywood pieces. There's enough work in drilling holes, assembling the parts and painting to meet the 51% rule, but Loehle's parts packaging makes it model-airplane easy. No band saw or table saw is needed, he says, as a coping saw to trim the parts should be sufficient.

The company estimates build time for the 5151 Mustang and P-40 kit at 800

LOEHLE 5151 MUSTANG

Price (excluding quickbuild options)	$10,995
Estimated completed price	$30,929
Estimated build time	800 hours
Number flying (at press time)	73
Powerplant	Rotax 582UL 65 hp @ 6200 rpm
Propeller	Warp Drive four-blade ground-adjustable
Powerplant options	65 hp

AIRFRAME

Wingspan	27 ft, 5 in
Wing loading	7.69 lb/sq. ft
Fuel capacity	5 gal (13 gal optional)
Maximum gross weight	885 lb
Typical empty weight	600 lb
Typical useful load	285 lb
Full-fuel payload	255 lb
Seating capacity	1
Cabin width	24 in
Baggage capacity	20 lb

PERFORMANCE

Cruise speed	85 mph (74 kt) 1000 ft @ 75% power, 4 gph
Maximum rate of climb	1200 fpm (at max. gross)
Stall speed (landing configuration)	30 mph (26 kt)
Stall speed (clean)	30 mph (26 kt)
Takeoff distance	150 ft
Landing distance	250 ft

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

LOEHLE P-40 FLYING TIGER

Price (excluding quickbuild options)	$10,995
Estimated completed price	$30,929
Estimated build time	800 hours
Number flying (at press time)	3
Powerplant	Rotax 582UL 65 hp @ 6200 rpm
Propeller	Warp Drive three-blade ground-adjustable
Powerplant options	65 hp

AIRFRAME

Wingspan	28 ft, 8 in
Wing loading	7.69 lb/sq. ft
Fuel capacity	5 gal (13 gal optional)
Maximum gross weight	885 lb
Typical empty weight	600 lb
Typical useful load	285 lb
Full-fuel payload	255 lb
Seating capacity	1
Cabin width	24 in
Baggage capacity	20 lb

PERFORMANCE

Cruise speed	80 mph (70 kt) 1000 ft @ 75% power, 4 gph
Maximum rate of climb	1200 fpm (at max. gross)
Stall speed (landing configuration)	30 mph (26 kt)
Stall speed (clean)	30 mph (26 kt)
Takeoff distance	150 ft
Landing distance	250 ft

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

hours, though a meticulous nitpicker will inevitably exceed the norm. A builder with a two-car garage should be able to put most of the replica together before trailering it to the airport.

Performance-wise, the Loehle WW-II replicas deliver exactly what the company promises: warbird fun without the challenges. Flight characteristics are gentle and predictable, allowing a competent tailwheel pilot familiar with the replica's light weight class to fly away with a little coaching. I didn't get to fly the KW-909 "Cherman" fighter, but I'd guess that it would share the manners of the American equivalents. I can envision the potential of creating a Hawker Hurricane from the P-40, and as the true hero of the Battle of Britain, it deserves to be replicated.

And while that project may have to wait, another is in progress. Spitfire enthusiasts will not be denied, and the long-awaited Loehle Spitfire Elite kit is moving forward. This in-development replica required a new wing design using a box spar that's 37 inches wide at the root, and the landing gear will swing outward like the original Spit's. The Malcolm hood of the canopy is correct, the shape of the wing and tail is properly elliptical and there will be a composite upper cowl over the Rotax 582. Loehle has set no timetable for its first flight, but my guess is that it won't be too far off. A comprehensive builder's manual will accompany the traditional drawings, a project that has taken considerable time.

So is a Loehle aircraft in your future? A homebuilt replica fighter is certainly a great way to indulge your aspirations without requiring warbird pilot skills, and Loehle's designs fit the bill. The company has almost 30 years of experience making dreams come true for us would-be defenders of the homeland, and I'm sure glad Mike Loehle stopped to buy that P-51 model all those years ago. ✢

For more information on any of the Loehle kits, call 931/857-3419. A direct link to the company's web site can be found at www.kitplanes.com.

Zenith's Four-Place STOL 801

The answer to the backwoods blues?

BY DAVE HIGDON

Few fields of endeavor offer more examples of specialization than aviation. In fact, so varied and focused are most aircraft designs that if flying were biology, it's easy to imagine Darwin developing the foundation of his theory on natural selection from observing the birds of Oshkosh, rather than the wildlife of the Galapagos Islands.

There are airplanes meant for speedy personal transport across long distances; airplanes meant for nothing-but-fun flying close to home; airplanes meant to haul heavy loads; airplanes meant solely for a single soul leisurely cruising low-and-slow across the landscape below. Even airplanes meant for cruising cross-country to backcountry patches of land barely big enough for wildlife to graze.

It's in this last category that Zenith Aircraft offers two machines: the STOL CH 701 two-place and the natural evolution of that long-time design, the four-place STOL CH 801. (STOL stands for short takeoff and landing, and in the case of the Zenith aircraft really means it.) Few instances exist in aviation of one design successfully evolving into a second machine that matches exactly the intent and performance traits of the original, particularly when a doubling of the seats is on the agenda.

But Zenith designer/patriarch Chris Heintz and his team of family engineers succeeded in doing just that with the 801. Exceedingly good at negotiating short fields, excellent in low-speed handling and solid in its space and load-hauling performance, the 801 should appeal to a builder in need of a machine capable of carrying four people—or the equivalent in people and gear—to places inhospitable to most other fixed-wing machines.

Starting With a STOL For Two

Heintz introduced the 701 almost 20 years ago as a two-place utility design to complement his speedy Zodiac model, shocking an industry unaccustomed to the radically cambered airfoil and no-kidding utility appearance. (Remember that the 701 arrived amid the Lancair/Glasair wars when sleek, plastic airplanes were all the rage.) Penned with easy construction, low maintenance and comfortable flying in mind, the 701 drew its strongest acceptance among pilots and operators in the so-called third world regions of the globe. With around 500 flying, only about one in five came out of builders' shops here in the U.S.—the complete opposite of the ratio between domestic and foreign sales of most kit designs.

The full-span fixed slats and flaperons distinguish Zenith's STOL 801 from the typical high-wing four-seater and contribute to the low-speed characteristics of the design.

Overseas, 701s serve as cargo haulers, crop dusters, spotting planes and missionary-support aircraft. Closer to home, farmers and ranchers use the 701 to patrol property, track cattle or wildlife, and serve in many the same roles as those fulfilled by small helicopters—albeit at a fraction of a chopper's costs.

Jump ahead a decade from the 701's introduction, and the Heintz finally had the time to answer market demand for a larger STOL design that retained all the traits that made the original a success. Pilots wanted more seats, more payload and more power; the four-seat STOL 801 was Heintz's response.

Simple Structure Equals Simple Construction

Although the 701 and 801 share neither airframe parts nor powerplant options, they do employ the same design features: high-lift airfoils, slats, flaperons, brawny tricycle landing gear and simple design for easy assembly. And as their common designations imply, they also share in their STOL performance and friendly flying characteristics.

When Heintz created the STOL 801 in the late 1990s, he employed many of the same engineering traits he'd long used on his prior designs. Simplicity of design was chief among them—and, where Heintz's aircraft are concerned, this also translates to simplicity of construction.

You need not look long at the 801 to discern his approach. The fuselage, for example, is basically a large tapered box braced inside to carry the power and flight loads. The skins are simple, flat pieces assembled with braces inside that join each other via riveted angles.

The wings employ a high-lift airfoil complemented by fixed leading-edge slats across their full span. Anyone familiar with the German Fieseler Storch STOL observation airplane or the workhorse Helio Courier likely knows about the moveable slats on their wings—they allow the aircraft to fly at airspeeds and angles of attack that would push other aircraft past stall and have them headed earthward. The slats work the same way on the 801—except without the complication of hardware that lets them retract. According to Heintz, a wing using both flaps and leading-edge slats has a maximum lift coefficient of 3.3—a conventional airfoil with flaps has 2.4, and without flaps it's 1.5.

The 801's horizontal surfaces appear inverted compared to more conventional aircraft, but the design—with its slotted elevator and full-flying rudder—enhances the plane's ability to climb steeply and fly controllably at very low indicated airspeeds.

The wings mount *above* the cabin, improving cabin access and visibility out the side windows. Skylights provide great visibility over the low wing in turns and an excellent window on the sky when flying straight-and-level.

Back at the empennage, Heintz gave the 801 a full flying rudder with an aerodynamic counterbalance; the horizontal stabilizer looks like it's mounted wrong—camber-side down. But this configuration provides maximum pitch control at the extreme angles of attack at which the 801 can fly, while the slotted


The front seats of the STOL 801 adjust to the pilot so that controls and switches fall to hand while taking advantage of the excellent visibility out of the cockpit. The tall, swing-up doors provide ample access to both front and rear seats.

Photos: Dave Higdon

elevators assure they get airflow at these high angles of attack so they continue to provide positive control.

And to assure the pilot of maximum control at all attitudes and airspeeds, Heintz gave the 801 full-span Junkers-style flaperons. Designed with their own airfoil, these surfaces mount on hinges just *aft* of and *below* the trailing edge of the wing. Hanging in undisturbed airflow, the flaperons serve as their name suggests—as both ailerons *and* flaps. A handle between the seats allows the pilot to control the flap setting. The Zenith-standard Y-type center stick provides both seats access to the control for the roll-input function of the flaperons as well as for pitch. (This arrangement means that you'll have to switch hands on the stick to activate the flaps, of course.)

Hardware For Hard Work

To that end, Heintz gave the 801 a sturdy tricycle landing gear that also provides the 801 pilot visibility as good as you'll find. (Conventional gear is not an option.) The main gear itself consists of a single piece of spring aluminum bent into a massive U; it bolts to the support structure through the bottom of the cabin. The nose gear uses a single bungee-cord suspension system on a telescoping strut and a saddle-type mount for the tire. It's effective, simple and strong. The nose wheel is directly steered through the rudder pedals, a hallmark of Heintz designs.

The wide instrument panel—it's a whopping 40.5 inches wide and 11 inches tall—allows for the installation of a dream panel with gyros, multifunction displays and all the communication and navigation gear you're ever apt to need. Of course, for those to whom simplicity is king, the 801 panel will look even larger with the bare minimum needed for safe, legal operation. Maybe you could paint a mural.

The cockpit itself measures an expansive 44 inches wide at the hip, 40 inches high from the seat bottoms to the overhead—and long enough for both front- and back-seat occupants to enjoy plenty of legroom. From the instrument panel to the aft seat backs, the cabin stretches 6 feet.

A pilot can stuff a lot into the 801—the combination of four occupants with luggage totaling 200 pounds each comes up 800 pounds; 180 pounds of fuel to fill the standard 30-gallon tanks leaves you with 70 pounds unused based on the company's estimated empty weight of 1150 pounds. The 801 employs a pair of welded-aluminum tanks that mount inside an inboard bay in each wing; each can carry 15 gallons. An option for four such tanks takes total capacity up to 60 gallons. The standard tankage may be marginal for the most popular engine option, the evergreen 180-hp Lycoming O-360. Zenith says the airplane is suited for engines ranging in power from 150-240 hp (as long as the installed weight does not exceed 440 pounds). With remote operators in mind, Heintz actually built the prototype 801 with a converted Subaru auto engine claiming benefits in fuel compatibility and spare parts availability. A few builders have opted for that route.

The Lycoming O-360 fits relatively easily into the 801's roomy engine compartment leaving ample room to work on accessories between the back cooling baffle and the firewall.

Designer Chris Heintz wanted the 801 to handle unimproved fields and firm STOL arrivals, so he designed the four-seater with a rugged one-piece leaf-spring main gear and a telescoping front strut that uses wrapped bungees to absorb shock loads.

Heintz gave the STOL 801 a cabin-wide instrument panel with space for as much equipment as you feel you need.

So Let's Go Flying

Thankfully, the simplicity of the 801's construction and control linkage make preflight inspection a relative snap. A hatch in the cowl provides access to check the oil in the O-360; pretty much everything else is visible to check by touch and sight. A standard walk-around inspection gives you the opportunity to ensure the integrity of the entire airplane. The top-hinged doors make access to the front seats effortless; flying with doors off is also an option.

The Lycoming four cylinder fires up just like thousands of other O-360s flying in general aviation. Taxiing to the runway at Mexico's (Missouri) airport gave us time for the engine to warm—which wasn't long

Zenith's back seats sit tall and straight, offer good legroom and plenty of elbow room—plus an excellent view out the large rear windows.

considering an OAT in the mid-90s. Directional control through the nose wheel steering was tight and precise—not too light, not too fast.

The normal runup completed, I turned onto the runway, applied full brakes, full flaperons, then full power; the tach wound to about 2350—normal for a Lycoming with a fixed-pitch prop—and I released the brakes. The 801 shot forward briskly, and as we approached the 200-foot mark I eased the stick back to full-up elevator.

The nose wheel lightened immediately, and as we passed the 300-foot mark the 801 literally vaulted into the air showing about 40 mph on the airspeed dial. For all the world, my cockpit seat suddenly felt like a recliner as I sat back and watched clouds grow larger in the windshield.

Lowering the nose to about 50, the 801 climbed at around 1200-1300 fpm; raising the flaperons and lowering the nose until I could see forward again brought the airspeed up to about 75 and still gave me a climb rate around 600-700 fpm. It was a little difficult to tell completely, since we kept flying through rising air that increased our climb. Throughout the initial minutes of my flight, the 801 responded quickly and positively to roll and yaw inputs. Even down at the lowest airspeeds, the 801 responded crisply to aileron—er, flaperon—inputs, doing nothing but increasing my confidence in this machine.

Surprise! Pure Speed Is Not Its Forte

As we passed through 4500 feet MSL, it seemed time to try a cruise setting in this STOL airplane. Level at 5500 feet with the tach showing 2450 rpm and the engine leaned to about 50° degrees rich of peak EGT, the 801 slowly accelerated to 94 mph indicated for 105 mph true—right on the book cruise according to Zenith's specs.

My own experience in a 180-hp O-360-powered Piper Comanche informed me of the cruise potential of the 801 set up for this power and cruise. With fuel flowing at just over 10 gph, an 801 pilot can expect to cover about 250 miles before hitting reserves; at lower power settings, cruise range edges up to about 300 miles—plenty for the pilot visiting local pastures but otherwise staying close to home. The optional 60-gallon fuel system effectively doubles your cruise potential.

OK, let's think about that for a moment. Many airplanes with the same power will see the Zenith in their slipstreams, no doubt about it. And, it has to be said, that the 801's impressive short-field prowess definitely cuts into its cruise speeds. There are other designs in the world of homebuilding that nearly match the 801's short-field prowess but offer fleeter cruise. Blame the high-lift airfoil—and there's plenty of it, at 167 square feet—and everything-hung-out-there design of the 801, if you must.

After all, it's in dropping into unimproved fields that the 801 truly shines—not long-distance cruising (although it can do so on the same terms as a Cessna

Zenith answered calls for a four-seat version of the STOL 701 (top) with the STOL 801. Heintz gave the Lycoming-powered 801 all the attributes that helped make the Rotax-powered 701 a success: the ability to launch from short fields and maneuver at very low airspeeds.

172 or Piper Cherokee with the same power).

Heads Down...

If going up flying is, as the saying goes, the second-greatest thrill, getting down to landing has to be the first-greatest. And the 801 gets down every bit as well as it gets up.

Setting up for an approach involves dialing in a 500-fpm descent at about 60 mph indicated with partial flaperons. As we crossed the runway threshold the first time, I slowed the 801 to 55, then 50, then pulled the power and eased back on the stick to full aft. The 801 rewarded me with a solid arrival—not so much a "plunk down" as a "touchdown." In three airplane lengths, I had the STOL stopped. Total landing distance—just about 300 feet.

Deep slips are a delight, but not recommended for long periods due to the unusual loads placed on the flat sides of the 801's fuselage. But you should know that in a pinch, the 801 does simply great slips at angles that make the ground seem to rush toward you. With the added practice of three more approaches, my arrivals grew smoother, my touchdowns less assertive, and my landing distances slightly shorter.

So spry in pitch was the 801 that in touch-and-go landings and rejected-landing maneuvers, I did have to focus on lowering the nose and raising the flaperons to avoid over rotation and an abrupt stall. But this issue was, like the improved landings, mostly a matter of familiarity and routine.

The least surprising aspect of the STOL 801 came in how it handles stalls. Power on, the 801 actually never stalled, instead continuing to climb about 100 fpm with the stick full aft and the nose pointed at a seemingly impossibly high attitude. Power off and with full aft stick, the 801 never really stalled for me. But it did settle into a nose-high mush that accelerated and decelerated through slight hints of dropping the nose. Our descent rate rose and fell between about 250 and 500 fpm with each porpoise-like attitude change.

Throughout these stall attempts, the 801 retained positive aileron and rudder control. And upon release of the back pressure on the stick, the 801 returned to climbing flight.

All in all, the experience was gratifying.

Need a "Bubba"? On a Budget?

Any pilot in need of a brawny bush plane should consider Zenith's STOL 801—even if they don't *really* need four seats. The 801 builds so easily, the Lycoming O-360 so common—or O-320, since 150 horses also work—and the fixed-pitch prop so well suited, that you'd be hard pressed to find another STOL aircraft with the capabilities and economies of this one.

The kit components come well finished and ready to assemble; an inexperienced builder should be able to go from opening the first crate to flying the first time in 300-500 hours—so says the company. This figure depends, as always, on the finish desired and the panel installed. Keep it simple and you'll keep the airplane light, cheap (or cheaper) and easy to build.

The STOL 801 offers a comfortable cabin with payload enough for four plus luggage and short-field performance that can take the little bush plane into almost any strip.

About the harshest thing I can say about the 801 concerns getting in and out of the back seats; it's a bit of a climb that the unfamiliar may find a bit challenging. Otherwise, for the pilot in search of a four-place cruiser with decent performance—and one that's easily built—the 801 has a lot to recommend itself...even if it's *always* pavement under its wheels.

You see, just because the STOL CH 801 is a special-purpose machine doesn't keep it from working well as a general-purpose airplane with four seats. It all depends on your purpose. Either way, the 801 will satisfy—and that's a specialty hard to duplicate.

For more information on the STOL CH 801, contact Zenith Aircraft at 573/581-9000. A direct link to the company's web site can be found at www.kitplanes.com.

ZENITH STOL CH 801

Price (excluding quickbuild options)	$20,950
Estimated completed price	$45,000
Estimated build time	300 - 500 hours
Number flying (at press time)	100+
Powerplant	Lycoming 0-360 180 hp @ 2700 rpm
Propeller	Sensenich two-blade fixed-pitch
Powerplant options	150 - 240 hp

AIRFRAME

Wingspan	31 ft, 4 in
Wing loading	12.9 lb/sq. ft
Fuel capacity	30 gal (60 gal optional)
Maximum gross weight	2200 lb
Typical empty weight	1150 lb
Typical useful load	1050 lb
Full-fuel payload	870 lb
Seating capacity	4
Cabin width	44 in
Baggage capacity	200 lb

PERFORMANCE

Cruise speed	120 mph (104 kt) 6500 ft @ 75% power, 10.5 gph
Maximum rate of climb	720 fpm (at max. gross)
Stall speed (landing configuration)	39 mph (34 kt)
Stall speed (clean)	48 mph (42 kt)
Takeoff distance	390 ft
Landing distance	300 ft

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

Power Play!

Dennis Douglas and his Lycoming O-320-powered GlaStar. "I named the GlaStar *Patti's Kitchen* because at the time I planned to purchase the kit, my wife (Patricia) wanted her kitchen remodeled. Being the thoughtful husband I was, that instead of a new kitchen I'd name the airplane after that kitchen." Douglas got out of the doghouse by subsequently buying her a new house with a new kitchen.

One builder deciphers the factory's charts and creates his own power charts for the Lycoming O-320. You can, too!

BY DENNIS DOUGLAS

The Lycoming Operator's Manual for the O-320-B and -D series of engines provides outdated power curves for these engines, "as they are manufactured and tested today." This article provides the corrected data and develops a simple mathematical approach for calculating power tables for those flying an O-320-B or -D series engine with a constant-speed propeller.

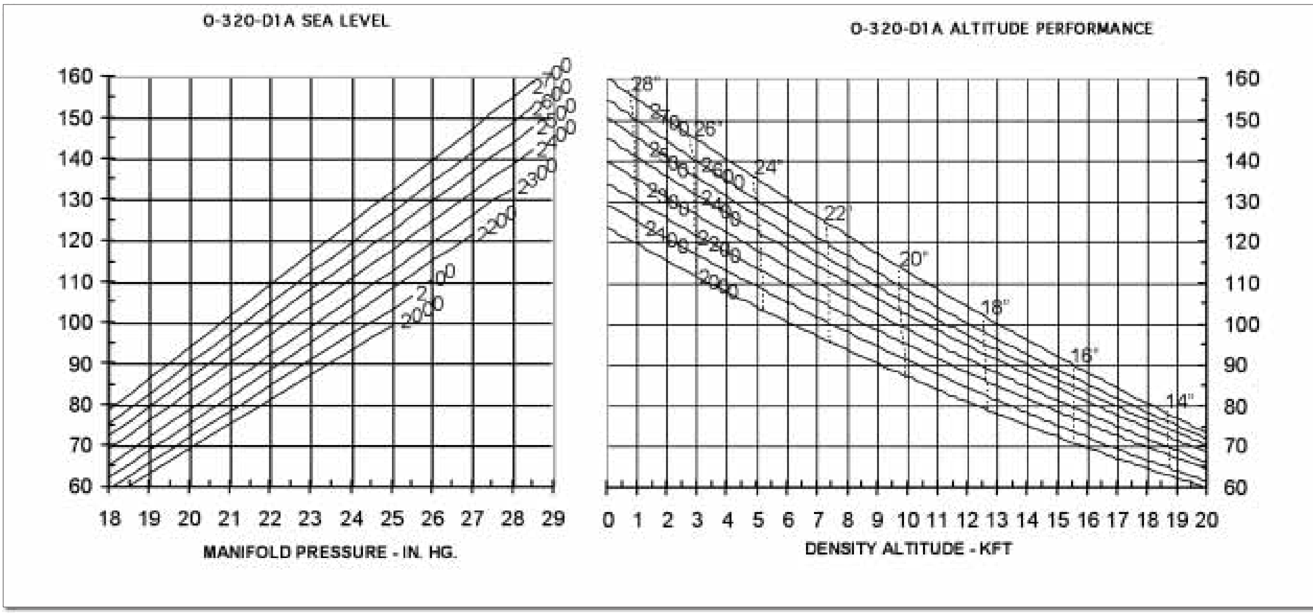
About six months before the first flight of my GlaStar, I started preparing drawings and data sheets for the Pilot's Operating Handbook (POH) that would be specific for my airplane, N9103D. My starting point for this was the GlaStar Owner's Manual, of course, but I've made numerous additions, deletions and changes to various pages, as those are indicated by the specifics of my airplane. The additions included schematics of the electrical system, checklist items, procedures, airspeed correction tables and a new Performance section.

For the Performance section in the POH, I wanted to include tables of engine power, fuel consumption and endurance as a function of manifold pressure, rpm and altitude. These tables are commonly found in the POH for other aircraft I've flown, and they are useful for flight planning as well as an in-flight aid for power and fuel management. To get the information I needed, I went to the Lycoming Operator's Manual for the O-320 engine series. This is a small, ring binder-type book, with a Textron Lycoming Publication number 60297-16.

The Sea Level and Altitude Performance charts for the O-320-B and -D series engines are found in Figure 3-6 of the Lycoming Owner's Manual. This figure shows two tiny, complicated graphs that allow the reader to scale off engine horsepower from manifold pressure, rpm, altitude and OAT. The combined graph is labeled "Curve No. 11260-A."

Douglas created his own tabular power charts for the O-320 with a constant-speed prop.

Figure 1. Power Chart for Lycoming O-320-B and -D Series Engines.



It's In There Somewhere

I got out my magnifying glass and started scaling off numbers. After an hour or two of frequently jumping a line on the graph and thus getting incorrect numbers, I called Lycoming and asked them if they had a larger version of the data in Figure 3-6. "Sure", they said, and they sent me a supplementary publication, No. 2283-H dated February 28, 2000, and entitled "Detailed Specifications for Engine, Aircraft: Model O-320-D1A, -D2A, -D1B, -D2B, -D1C, -D3C, -D2G, -D3G 160 Horsepower Direct Drive." The power chart for the O-320-B and -D series engines in 2283-H is labeled "Curve 13381."

A problem arose when I compared Curve 11260-A with Curve 13381: For a given rpm and manifold pressure, the horsepower values were significantly different—typically by about 5 hp or about 3% in percent power. The fuel consumption rates were different also—by several gph.

I called Lycoming to find out which of the two pairs of curves were correct: 11260-A shown in the Operator's Manual or 13381 shown in the Detailed Specification document. After a time I got an answer: "The performance data on curve No. 13381 is representative of the O-320-B and -D as they are manufactured and tested today." For those of us who are trying to define the operating parameters of our airplane with the same care we used building the airplane, this says that the horsepower data shown in the Operator's Manual is out of date. Curve 13381 is the correct one to use.

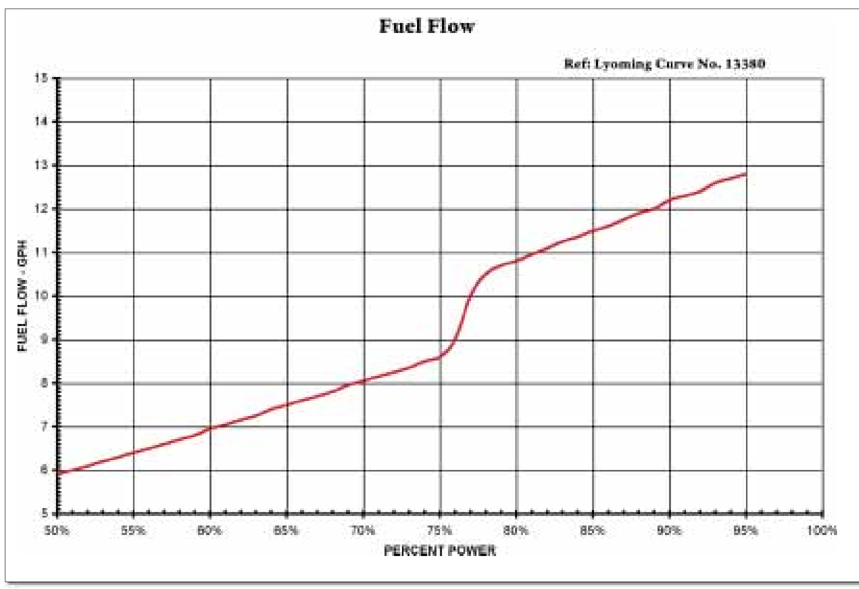


Figure 2. Fuel Consumption for O-320-B and -D Series Engines (Ref: Curve 13380).

It's About Horsepower

Curve 13381 is a hand-annotated, rough-drawn chart. I scaled the data from the curve, entered the values into an Excel spreadsheet, and used regression methods to develop a set of curves that represent Curve 13381 in a more readable form. After changing the axis title to show the altitude data as a function of density altitude (to automatically compensate pressure altitude for deviations from the standard altitude-temperature relationship), the results are shown in Figure 1. This power chart, then, is a corrected power chart applicable to the O-320-B and -D series engines and should be used instead of Chart 11260-A in the Operator's Manual.

Photos and Illustrations: Dennis Douglas

Horsepower at sea level. For the sea-level data—the family of lines on the left side of Figure 1—the horsepower curves were calculated by finding simultaneous linear relationships from the data in Curve 13381, as described above. The relationship developed for the sea level data shown in Figure 1 is:

HPSL ≈ (0.0022 x rpm) x MP + (1.6733 x mp) – (0.0081 x rpm) – 36.176, where rpm is the engine rpm, MP is the manifold pressure in inches, and the (x) indicates a product. This equation allows us to calculate horsepower for arbitrary rpm and manifold pressure values.

I first saw this approach used in the work of John Lowry—see his book, "Performance of Light Aircraft"—who developed his equations following a thorough review of engine theory. Although the equation differs slightly from the expression Lowry obtained, it is based on the data I measured using Curve 13381. The differences are minor and you could use either equation with no significant loss of accuracy.

You will note that the sea-level data shown in Figure 1 does not extend over the full range of manifold pressure for all rpm values. This is a result of using the "limiting maximum manifold pressure for continuous operation" described in Chart 11260-A and applying it to the data of Figure 1. Thus, Figure 1 shows the limiting "oversquare" power settings (evidently) permitted by Lycoming for the O-320-B and -D engines. For example, while 2300 rpm and 28 inches of manifold pressure is permissible, a maximum of 25 inches is permitted for 2000 rpm for this engine.

Horsepower at altitude. While we could use this equation to generate a table of horsepower as a function of manifold pressure and rpm, it would represent only the sea level values. This is because horsepower increases with altitude for a constant manifold pressure and rpm. This power increase with altitude is due to the reduced exhaust backpressure as altitude increases—a phenomenon noted by both Lowry and John Schwaner in his "Sky Ranch Engineering Manual." The reduced backpressure increases the thermal efficiency of the engine, thus yielding additional power. So, to obtain the horsepower at altitude, we must use the right side of Figure 1.

5000 Feet — CRUISE POWER CHART – BEST POWER LEAN

RPM	M.P. (in)	HP	% PWR	FUEL RATE* (gal/hr)	MAIN ENDR. (hr)	MN + AUX ENDR. (hr)
2200	19.0	80.3	50%	7.4	3.9	6.5
	20.0	86.8	54%	7.8	3.7	6.2
	21.0	93.4	58%	8.2	3.5	5.9
	22.0	99.9	62%	8.7	3.4	5.5
	23.0	106.4	66%	9.1	3.2	5.3
	24.0	112.9	71%	9.6	3.0	5.0
2300	19.0	83.7	52%	7.6	3.8	6.3
	20.0	90.4	57%	8.0	3.6	6.0
	21.0	97.2	61%	8.5	3.4	5.7
	22.0	103.9	65%	8.9	3.3	5.4
	23.0	110.6	69%	9.5	3.1	5.1
	24.0	117.4	73%	9.9	2.9	4.9
2400	19.0	87.1	54%	7.8	3.7	6.2
	20.0	94.0	59%	8.2	3.5	5.9
	21.0	101.0	63%	8.8	3.3	5.5
	22.0	107.9	67%	9.2	3.2	5.2
	23.0	114.9	72%	9.7	3.0	5.0
	24.0	121.8	76%	10.5	2.8	4.6
2500	19.0	90.4	57%	8.0	3.6	6.0
	20.0	97.6	61%	8.6	3.4	5.6
	21.0	104.8	65%	9.0	3.2	5.3
	22.0	112.0	70%	9.5	3.1	5.1
	23.0	119.1	74%	10.0	2.9	4.8
	24.0	126.3	79%	12.0	2.4	4.0
2600	19.0	93.8	59%	8.2	3.5	5.9
	20.0	101.2	63%	8.8	3.3	5.5
	21.0	108.6	68%	9.2	3.2	5.2
	22.0	116.0	72%	9.8	3.0	4.9
	23.0	123.4	77%	11.5	2.5	4.2
	24.0	130.8	82%	12.5	2.3	3.9

* REF: Lycoming Curve 13380; minimum consumption leaned to best economy for power <75% and best power for power >79% PLUS 1.5 GPH.

Figure 3. One of several completed power charts, this one for 5000 feet.

Correct But Awkward

Although correct, the data of Figure 1 remains awkward to use. To calculate a power, we enter a manifold pressure and rpm on the sea level chart and draw a straight horizontal line to a preliminary power value on the right side of the sea level chart. Then we locate the manifold pressure and rpm on the altitude chart and draw a straight line from there to the same preliminary power value on the left vertical axis of the altitude chart. On this second line, we locate the density altitude and draw a horizontal line from there to obtain the actual power value.

Using a similar simultaneous equation approach as used for the sea level data, we can infer the relationship for the power gain with altitude. Lowry shows that for the O-320 engines the horsepower increases by about 2.36 hp/1000 feet near sea level and by about 1.87 hp/1000 feet near 10,000 feet. Making a linear estimate of this change in horsepower with density altitude gives us a relationship for the actual horsepower: HPDA ≈ HPSL + DA x (-0.049 x DA + 2.36), where DA is the density altitude in 1000s of feet and HPSL is the horsepower scaled from Figure 1 or calculated from the sea-level equation. The use of this second equation allows the development of power tables for arbitrary altitudes through simple spreadsheet calculations. This is illustrated later.

Fuel consumption. As for the power charts, the fuel consumption data shown in Curve 11260-A of the Lycoming Operator's Manual may overestimate the actual fuel burn rate. Curve 13380 in Lycoming's publication No. 2283-H provides more recent information. This consumption curve is shown in Figure 2.

As described by Lycoming, this data "...portrays the *minimum* fuel consumption of

Even Easier...

Dennis Douglas' experience developing an accurate power chart for an unusual engine/prop combination is without a doubt a worthy endeavour, one that you'll want to commit to completely fill out your flight testing. But there are shortcuts that will work to get your in the horsepower ballpark as long as you have an accurate measure of fuel flow. (Thanks to the Advanced Pilot Seminars for this tip.)

It works like this: Every engine has a range of what is called brake specific fuel consumption, expressed in pounds of fuel per hour per horsepower (pph/hp). Any engine may run at any point in its range depending upon the mixture strength at the time. But the upper and lower limits are set by the design of the engine, principally its compression ratio. (There are other factors, including ignition timing and volumetric efficiency.)

Most engines produce maximum power at a BSFC of 0.5, or one-half a pound of fuel per hour per horsepower. A 200-hp engine would, therefore, consume nearly 17 gph (200 hp x 0.5 = 100 pph/hp. Divide by 5.85, the weight of fuel, to get 17.09 gph.) Minimum BSFCs vary greatly but always occur at a lean-of-peak EGT setting. The best aero engines achieve a BSFCmin of 0.385. Typical normally aspirated engines range from 0.39 to 0.41. Lower-compression engines are typically in the range of 0.42 to 0.45.

Working from that, it's easy to come up with a quick calculation of horsepower as long as you know fuel flow. (And know it accurately, let us say again.) When lean of peak, use 5.85 (fuel weight)/BSFCmin. Assume your engine is good for 0.4 and it's burning 14 gph. Your benchmark number is 14.6, which can be multiplied by 14 (the fuel consumption), gets you 204 hp.

That's the lean figure. Rich figures work similarly but have greater likelihood of error because the efficiency curve has a greater slope than the horsepower curve. Taking the same hypothetical engine from above, the multiplier would be around 11.7, giving you an estimated 154 hp.

Why less power on more fuel? Well, that's the whole rich-of-peak/lean-of-peak argument in a nutshell.

—Marc Cook

these engines with the mixture manually leaned to best economy below 75% power and best power above 79% power." Fuel consumption rates for best power are about 1.5 gph greater than shown in Figure 2. (The charts show that best economy is obtained near peak EGT or slightly richer, and best power is 100°-150° rich of peak.)

Using the information from the altitude equation, the fuel flow data from Figure 2, and some fuel tank volume data, we can put together tables of horsepower, percent horsepower, fuel flow and endurance as a function of manifold pressure and rpm for any altitude. One such table is illustrated in Figure 3, which shows these parameters for a (density) altitude of 5000 feet.

(Note that the fuel flow rates shown in Figure 3 are greater than the data shown in Figure 2 by 1.5 gph. I did this to be conservative in the endurance estimates to reduce the risk of running out of fuel because I usually lean to best power instead of best economy.)

All that's left is to fly the airplane and gather some airspeed data to complete the table.

Using the equations above, one can create tables of O-320-B and -D engine performance for arbitrary altitudes. These tables can be printed and inserted into the POH and used for flight planning and en route monitoring.

Wasn't That Simple?

This article has examined the performance of the Lycoming O-320-B and -D series of engines using recent information provided by Lycoming, and it develops a simple arithmetic approach for calculating horsepower and fuel flow for any specified manifold pressure, rpm and (density) altitude for these engines. The approach described here can be applied to any normally aspirated engine. The values will differ, of course, but the approach remains the same.

The actual horsepower generated by an installed engine may differ from the calculated values because of induction and exhaust differences, the general condition of the engine and because of high humidity or other factors. ✈

New Digs For the Ultimate Homebuilt

SpaceShipOne now calls the National Air and Space Museum's Milestones Gallery home.

BY CORY EMBERSON

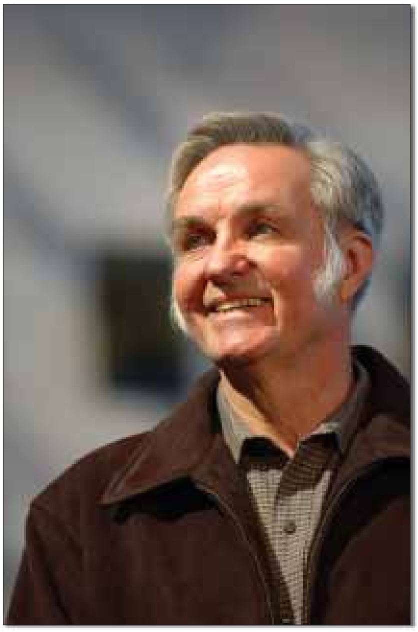
SpaceShipOne sits between its two new neighbors in the Milestones of Flight gallery: *Spirit of St. Louis*, at left, and the Bell X-1 *Glamorous Glennis*, to its right.

A chance like this doesn't come everyday. The story of *SpaceShipOne*, the first manned civilian craft to return safely from space and the winner of the Ansari X-Prize, has been well documented. Its final flight, from Oshkosh to Dulles International, brought it into truly sublime company...the Milestones of Flight Gallery at the Smithsonian Institution's National Air and Space Museum (NASM). It would be the first major hanging addition to the Milestones Gallery since its opening in 1976. *SpaceShipOne* would be among famous company, tucked between the *Spirit of St. Louis* and the Bell X-1, *Glamorous Glennis*.

Just down the hall from *Voyager,* another Burt Rutan creation, *SpaceShipOne* was unveiled on October 5, 2005, less than a year and a half after its maiden voyage into space. And we couldn't pass up the chance to witness the induction ceremony. But the public's first glance at the exhibit was just the final piece of a long process to acquire the aircraft and create the exhibit.

Building and Preserving the Collection

Valerie Neal, *SpaceShipOne*'s curator, says her role at NASM is to identify potential additions and to make the case to the museum for those deemed worthy. Neal had her eye on Rutan's aircraft from the start. "When the first flight into space occurred in June 2004," she says, "we decided to pursue *SpaceShipOne*, whether or not it eventually won the X-Prize."



Heralded homebuilder and *SpaceShipOne* designer Burt Rutan worked closely with the museum staff to orchestrate the hanging of the aircraft. *Voyager*, another of his creations sits just down the hall.

Photos: Patrick Matthews, Cory Emberson, Courtesy NASM

But Peter Jakab, chair of the aeronautics division and curator of the Wright *Flyer*, says that artifacts are not normally brought directly to the NASM immediately following record-setting flights. The museum follows a carefully detailed collection rationale intended to create a comprehensive collection.

The museum's collection mandate is twofold, says Ed Mautner, who led the Space Shuttle *Enterprise* restoration team. "Our goal is not only to preserve the object, but also its technology. If someone restores an airplane, their goal is to make a more pristine example of the airplane, and they cast aside a lot of the original technology, finishes and hardware. We want to save that, because we're not only trying to show the airplane to the public, but it's also there for future engineers, researchers and historians. We don't want to confuse them as to the exact technology at the time." For the museum, restoration, the most intrusive form of preservation, only takes place when the aircraft is so deteriorated that it can no longer show its original form or stand on its own without major work.

So you hop out of bed in the middle of the night for a drink of water, and what do you see out your kitchen window? *SpaceShipOne* rolling by at 1 a.m.? Might have been like that for a few lucky D.C. residents.

Neal and the museum's director, General Jack Dailey, wrote to Scaled Composites asking if they would consider donating *White Knight* and *SpaceShipOne*. Rutan and sole investor Paul Allen, co-founder of Microsoft, requested a meeting immediately following the second X-Prize flight. Neal and Tony Carp, the pilot/A&P responsible for the preparation and hanging of *SpaceShipOne*, visited Scaled Composites in December 2004 to meet the team and begin the process of adding the craft to the Milestones collection. Carp calls his visit to Mojave a career highlight: "Burt Rutan and Paul Allen's representatives were prepared to push hard to get it into the Milestones Gallery, but we already had that on the table. So, when we presented that to them, Burt Rutan had this *big* smile on his face, because that was exactly what he wanted. He wanted to see it in Milestones."

Neal presented a proposal to the permanent collections committee. In this case, it was easy—its technical and historical significance made approval a slam dunk. Next, it was time to work out the delivery and display of the machine.

There were several iterations of how *SpaceShipOne* might have been displayed; the result has it hung at a 30° nose-up attitude facing the space where the Wright *Flyer* will once again hang. Carp says, "The Milestones Gallery is kind of a conservative gallery, because its central focus is the Wright *Flyer*. It was important that *SpaceShipOne* wasn't *too* dramatic, which would distract from the main theme of the gallery. That's where the months of give and take came in. Mr. Rutan's initial thought was to hang it 45° nose-up."

As *SpaceShipOne* was hoisted to its display position, the collections team took the rare opporunity to capture this overhead perspective of the gallery through the open skylights. The strongback is the white pipe running diagonally across the photo.

Once the final configuration was agreed upon, the exhibit design group created a 3-D model to define the exact space it would occupy in the gallery. Carp's job was then to design the cable structure to support the craft between the *Spirit of St. Louis* and *Glamorous Glennis*.

Rolling Towards History

In August 2005, *SpaceShipOne* and *White Knight* flew directly from their splashy appearance at Oshkosh to Wright-Patterson Air Force Base in Ohio, where it refueled and stayed overnight (it's not outfitted to fly at night). The next day, it continued to Dulles Airport, home to the Udvar-Hazy Center, NASM's immense companion display facility.

Carp was on hand when *SpaceShipOne* arrived, piloted by Mike Melvill. "They filed IFR into Dulles, flying in VMC conditions," he says. "Mike was concerned about the ADIZ and didn't want to fly in looking like he had a missile strapped to his belly. We did the delink separation of *SpaceShipOne* from *White Knight*, and then we turned *White Knight* and got them out of here. We towed the little spaceship down to the Udvar-Hazy Center, which has its own taxiway. It was blazing hot that day, but everybody in the building came out just to get Mike's autograph and to shake his hand."

And they weren't the only fans. "Airliners were taxiing by, and they'd just stop. Then you saw the little cockpit side window open up, and the camera would come out." It was memorable. An airline seatmate was on one of those planes—the captain taxied in S-turns so the passengers on both sides of the plane could get a glimpse.

Once the gawking was over, they towed *SpaceShipOne* on its landing gear from a truck. The craft was prepared, cleaned and photographed while in storage. The systems were drained and any tanks under pressure were purged. Mautner noted this was the ideal way to bring an artifact into the collection. "It comes directly from the field immediately after its use, in the condition that it was in when it was used, and all we have to do to preserve it is to empty those fluids, clean it, and hang it up in a near-perfect environment."

Oh, and take a hammer and bang it up a bit, of course! After *SpaceShipOne*'s first flight, a panel buckled, which Scaled Composites straightened out for the second flight.

SpaceShipOne in its final 30° nose-up position in the Milestones of Flight gallery. Each artifact is positioned to face the center of the gallery, where the Wright *Flyer* will eventually hang again.

Prior to handing it over to NASM, the company rebuckled the panel to bring it closer to its original flight condition. Wonder who got that job?

On September 19, *SpaceShipOne* was loaded on a flatbed to transport it to the museum in downtown Washington, D.C. Carp was one of the escort drivers and described the process as intensive. The transport occurred at night and the caravan followed a specific route, which the team had carefully planned to ensure that the 26-foot-wide *SpaceShipOne* would make it through every overpass, exit ramp and side street. The spaceship was brought into the museum through immense sliding bay doors on its west side.

Rebekah Brockway designed the placement of *SpaceShipOne* in the gallery using 3-D AutoCAD software and found that double-checking the plans was crucial. "The *Spirit of St. Louis* was supposed to be hanging parallel to the floor, but when it was reskinned and rehung a few years ago, they attached a cable differently and the left wing was banked slightly lower," she says. "Had we not caught that, *SpaceShipOne* would have been too close to *Spirit* for comfort."

Working the Problem

True to *SpaceShipOne*'s spirit of innovation, the actual hanging of the craft was another first. Carp created a rigging design that worked around the building's structural issues. Nothing could be supported from the upper trusses under the gallery's skylight. So a strongback—a 27-foot long, 750-pound stainless steel pipe—would be hung from the lower trusses to support the 2408-pound craft. Using a crane to lift the spacecraft to the strongback couldn't be done inside the gallery because the suspended floor would not support the load. Former collections chief Bill Reese suggested putting an industrial crane outside on Jefferson Avenue and dropping the cables through the open skylight. It had never been done at the museum before, but it worked.

After the roof tiles were removed and the skylight opened, the crane operator lowered the cable, picked up the strongback and put it into place. Two clamps connected the strongback to the main hanging cables, which were sized to orient the craft properly. The same cable that lifted the strongback was also used to lift the craft by 5/8-inch oval rings. The main cables were already hanging from the strongback; a swaged eye at the end of each cable would attach directly to the two lift pins used to support *SpaceShipOne* under *White Knight*. Because the craft was supported vertically under *White Knight*, Carp asked Scaled Composites to verify whether *SpaceShipOne* could handle an off-center load after the nose-up attitude was introduced. It would be fine—each fitting was sized for 12,000 pounds with a 1.5 safety margin.

Carp described the transfer: "We brought the spaceship up so that the cables would reach. We made that connection and started to lower the spaceship to accomplish an in-air load transfer. The shackle rolled around the oval ring, and the shackle, which is already attached from the crane, rolls out of the way. The load was transferred from the crane to the support cable. That's very dramatic and it made a nice big *pop*! It went very smoothly."

SpaceShipOne was raised off the ground horizontally; once the load was transferred from the crane to the cables, the landing gear was retracted and the nose-up attitude was introduced. The successful transfer validated Carp's hanging scheme. The high-wing craft was stable from a c.g. standpoint, and it stayed between the two hanging points without trying to roll. He also installed two tag lines at the far end of the tail to control the yaw, preventing *SpaceShipOne* from hitting *Spirit of St. Louis* during maintenance.

The overnight installation took 12 and a half hours to complete. "It eliminated having to work around the building's constraints," Carp says. "The structural engineers were quick to tell me what they *couldn't* do, but they had no suggestions what *to* do. It's not a very heavy aircraft. There were a lot of brains working the problem."

Raising the Curtain

By the time *SpaceShipOne* was undraped the night before the ceremony, the exhibit was fully in place.

An interactive, computer-based video kiosk was designed by Susan Cassabon and Victoria Portway, a radical change from the simple text labels that accompany the rest of the exhibits. A virtual 360° tour of the cockpit is included in the kiosk. By moving your finger around the screen, you can essentially enter the cockpit. "Once it's hung, no one has access to the cockpit, and everybody wants to see it," Portway says. The images are also available on the museum's web site.

The relatively low-key induction event featured a video review of *SpaceShipOne*'s achievements, and of course, remarks from the principles. Rutan challenged American companies to bring civilians into space, safely and in the spirit of competition. He compared NASA's development of operational systems to the FAA running the airlines.

SpaceShipOne, Government Zero

Neal appreciates the significance of acquiring such a piece of history. "If I were a curator in an art museum," she says, "this would be comparable to acquiring one of the great masterpieces. It's in beautiful condition, and we were able to talk to the people who were directly connected with it.

A Flight of Firsts

As *SpaceShipOne* passed 100 kilometers before arching back to earth on June 21, 2004, pilot Mike Melvill earned the world's first Commercial Astronaut rating, complete with gold wings. Brian Binnie became the second to earn this exceedingly rare prize less than six months later, as Burt Rutan's latest creation captured the elusive $10 million X-Prize.

The first Commercial Astronaut wings are the brainchild of the FAA's Michelle Murray, an aeronautical engineer in the Office of Commercial Space Travel (AST) who served as the lead safety inspector for Melvill's historic suborbital flight. Murray wanted to recognize the achievement with an appropriate set of wings that combined the features of both NASA and FAA varieties. The entire process took only four weeks from start to finish—considered lightning fast in government circles. Murray presented the idea to her boss, Assistant Administrator Patricia Grace Smith, who then got quick approval by FAA Administrator Marion Blakey and DOT Secretary Norman Mineta. Smith presented the wings to Melvill the afternoon of *SpaceShipOne*'s first flight into space, listed modestly on the AST website as Flight 15P.

Murray's enthusiasm for the event was apparent as she recalled Melvill's reaction to receiving his gold-plated wings. "They didn't tell him in advance," she said. "When he opened up the box, the look on his face was sheer surprise. He was in awe!"

Since the practical test standards for the Commercial Astronaut wings haven't appeared in your local flight school (yet), Murray told us that to earn them, "all you have to do is go into space and return safely." —*C. E.*

"*SpaceShipOne* was done by a small group of people, working together and being really dedicated. Burt Rutan is legendary in the aviation world and is such an innovative thinker. It was quite exciting that he's moved beyond atmospheric flight into space flight. It's a homegrown, grassroots activity, using their own wits and some very generous sponsorship."

Neal says the design's creativity reflects Rutan's liveliness. "It's on a human scale. It's not something perched on top of a 15-story rocket. He says it should be fun—that's the reason to go into space."

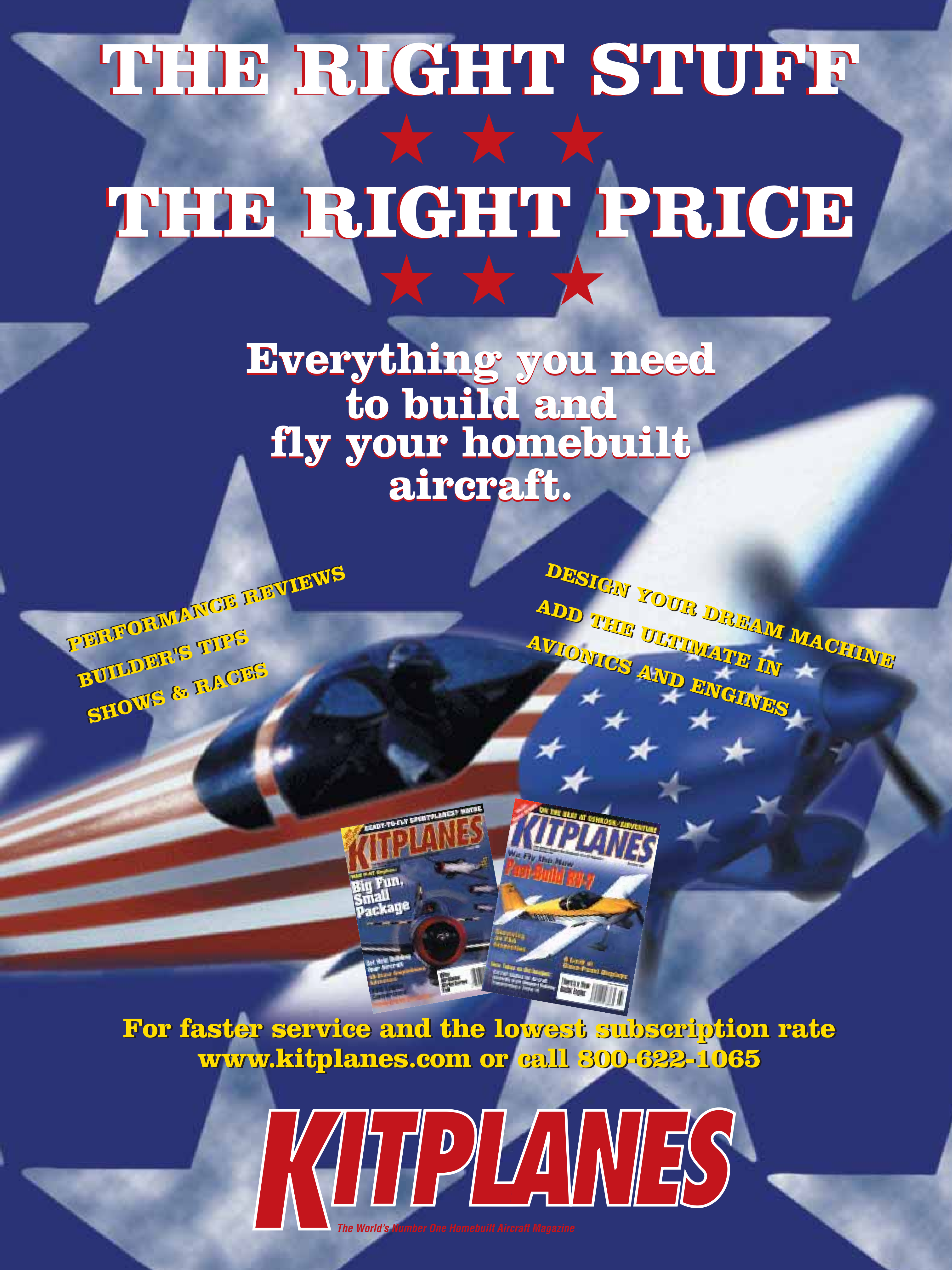
That's certainly true. After *SpaceShipOne*'s first flight into space, Melvill held a spectator's sign aloft while standing on the craft: "*SpaceShipOne*, Government Zero." Rutan saved the sign, a scorecard for the little guy.

Carp also came away awed by the machine: "The way he integrates all these systems into an amazingly simple single entity—that's the really impressive thing about it," he says. "The cockpit almost seems rudimentary...except for the data-link system and the tiny little displays that give you all the information you'd ever want to know. It's several unique, independent modes of flight, all incorporated into a single vehicle. Burt Rutan is probably the most innovative designer working, so it's stuff that winds up in the museum." Indeed—there are five other Rutan aircraft in residence at the Smithsonian.

Dorothy Cochrane, curator of *Voyager*, says, "Back then, he was this homebuilt guy with some weird ideas, proving himself, and he's proved himself so many times. It tickles me to see this be such a spectacular success. He wants to bring aviation and space travel to the common man, and have it be accessible. As a designer and a visionary, it's a challenge when someone says, 'You can't do that' when it's the first thing he wants to do."

Sounds like the spirit of a true homebuilder. ✢

For more information on the exhibit, contact the National Air and Space Museum at 202/633-1000. A direct link to the museum's web site can be found at www.kitplanes.com.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Product Review: AvMap EKP-IV

This combination GPS and chart plotter may not feature every bell and whistle, but it serves its niche admirably.

BY RICK LINDSTROM

About two thirds the size of your typical chart, the EKP-IV fits nicely in small cockpits without sacrificing legibility. The supplied GPS antenna comes with a long 5-meter cable, which is flexible and thin enough to route inconspicuously in most aircraft.

Murky! This mid-July day found our little two-seater fighting stiff headwinds over Pennsylvania's Allegheny Mountains as we clawed our way westward. Above the scattered-to-broken layer, the winds kept our forward progress down near what an old '65 Volkswagen bug might do on a good day. Below the layer, the visibility dropped well into the marginal VFR range, but the headwinds were much lighter. So there we were, in an unfamiliar airplane flying VFR over an unfamiliar part of the country, in weather conditions that were making this pilot sweat even more than usual. It was time to land and study our options. But where? There wasn't a whole lot to see outside the window but murk.

The answer came almost instantly with a few button pushes, accessing the database in the AvMap EKP-IV (Electronic Knee Pad). The EKP instantly became the world's most knowledgeable and sharpest navigator. Pressing the Page button displayed the 20 nearest airports, indicating that Mid State Airport was just a few minutes south. Thumbing the small joystick quickly highlighted the entry, and hitting the Goto button instantly changed our destination to the new oasis.

As we descended toward the terrain and the visibility decreased even further, the EKP-IV tracked our progress toward the airport and displayed a plethora of airfield-specific information, such as elevation and radio frequencies, while providing the usual GPS readout stuff. Our direct route to the field was shown as a solid black line, our actual course in white, and our predicted flight path preceded the little airplane icon and showed instantly if we drifted even slightly off course. Even in the hazy sunlight, the display was readable with large, crisp characters and graphics over a 7-inch-diagonal screen.

With the cartographic scaling function in the Auto mode, the airport loomed both larger in real life and on the EKP's screen as we closed in. Very nice.

Ho Hum?

It's true: There are a bunch of similar GPS devices that do all this and more, portable units that provide real-time weather overlays and even the latest TFR depictions through XM satellite subscriptions. So why doesn't AvMap do the same? "We keep talking about adding real-time information," says Mark O'Brien, the company's technical support specialist. "But we don't use the Windows operating system, like the others do. You've got to be Windows-based to interface with XM." So, as nice as it would be to have XM-based, real-time functions, it would require a complete redesign of the EKP-IV right down to the operating system.

But before you turn up your nose at the EKP-IV, you might want to consider the things that it *does* do. To start, its relatively large footprint makes it easy to read the bright screen in either a horizontal or vertical orientation, your choice. Only the tablet-based systems are bigger, and frankly, some of them are just too big to be comfortable in a tandem airplane or narrow cockpit. To get an idea of how big the EKP-IV is, grab a sectional and fold a third over. What's left is just a bit bigger than the EKP-IV. (The unit's actual dimensions are 4.75 inches wide by 7 inches high by 1.5 inches deep.) After flying with it for nearly 80 hours in two different airplanes, we found the size ideal for strapping to your thigh.

And, the EKP-IV is easy to use. All of the buttons used for navigating around the unit's functions are arranged around two sides of the perimeter, leaving the majority of the space available for the screen. A small rubber-covered joystick is positioned in the corner where the two button rows intersect, and it's a cinch to cruise through the menus or position the

Photos: Rick Lindstrom

cursor with thumb or forefinger. The unit looks so svelte at first glance that you might think it short on value, but when you bring up the Menu function and delve deeper into the various levels, you can see just how capable the EKP-IV really is.

Terrain, Too!

By the time we loaded the airplane and launched toward Oshkosh from Northern California, the afternoon had already grown late. We planned to make our first overnight stop in Winnemucca, Nevada, a short 2.5-hour jaunt from home. As we crossed over Reno eastbound, day quickly became night, and outside visual references dwindled until only the thin ribbon of headlights below on Interstate 80 was visible. Compounding the lack of outside visual references, our course paralleled a line of thunderstorms some 15 miles to the south, building over a mountain ridge. Every few seconds, a spectacular flash of lightning would illuminate the area flashbulb style, immediately followed by a deep darkness that greatly resembled the inside of a cow.

In an area of the world where high mountain terrain is all around and mostly invisible under these conditions, knowing exactly where the peaks are is invaluable. The EKP-IV provides color-coded terrain mapping, so a quick glance is sufficient to stay clear of the *cumulus granitus*, and moving the cursor to any point on the screen provides instant elevation data as well. Not sure if your altitude is sufficient? Simply move the cursor to any given point on your course line and you'll know immediately. Does your planned direct course take you too close to high terrain during descent? Move the cursor away from the evil airplane-snatching obstacles and hit the Goto button. Bingo! You have a new course. Man, flying safely into Winnemucca VFR at night was never so easy.

There are six user-selectable data blocks to customize with a wide variety of presets. The bottom right block has been programmed to display internal battery status, and the bearing and distance to the cursor from present position is immediately below.

More, More, More

Imagine an illicit affair between a capable electronic E6-B flight computer and a fully functioned GPS, and the offspring would have most of the features of the EKP-IV. Toss in the ability to store multiple flight plans, checklists and the like, and now you're getting closer. Add the ability to customize what information you choose to have displayed in the available data blocks and what is displayed on the navigation screen at each cartographic scale level, then wrap it up in an elegant package with a crisp TFT display.

The EKP-IV is almost infinitely tunable to work as the primary navigation tool, or interfaces nicely with the rest of the stuff in your panel. It will accept GPS data from another source when used only as a display, and flight plans can be up- and downloaded to your PC with optional software and an interface cable.

The comprehensive aeronautical database in the EKP-IV is stored in an easy-to-swap flash memory Jeppesen NavData card that is updated every 28 days. The unit comes with the latest NavData revision, and it's the owner's choice as to how often to update from there. Individual updates cost $79.99, an annual subscription for 13 updates costs $599.99, and the three- and six-times per year updates fall between. Of course, it doesn't legally replace having current charts in the cockpit, but it's really hard to go back to flying the "old" way without the EKP once you've become used to flying with it.

How so? Well, 400 miles west of Oshkosh, we found ourselves playing around with waypoint entries and managed to hit some combination of buttons that sent the

Even under bright conditions, the unit's spacious display is easy to read. The blue line preceding the aircraft icon is predicted course.

The actual flight path is shown as a white line, and you can see the tail of the aircraft icon disappearing at the very top of the display.

system into an endless power-up cycle. At the AvMap booth, the tech support guy mentioned a function called "RAM Clear," which flushes all waypoint and flightplan data from RAM. You really have to know where to look to find this in the manual (Page 93, if you're curious) as it's not at all intuitive that the constant power-up reset attempts are due to improper data sitting in RAM.

Undoubtedly, some enterprising homebuilder has already mounted an EKP-IV semi-permanently in his panel,

Here's only the first page of an incredible amount of airport data available by placing the cursor over the airport graphic.

given its easy-to-read display. This might be the perfect time to use a Velcro-style mounting system, as you'll want to access the back of the unit. Although all of the external connections are arranged on a single end, where the NavData card also resides, the unit also has a battery well on the back that uses six AA cells for roughly an hour of backup power. The EKP does not have a built-in charger function to re-energize the rechargeable variety, so replacing those batteries in flight (in the event of external power loss) may be something to anticipate.

Minimum Ugly

Nothing in this world is perfect, and the EKP-IV has its share of things that we think could be improved. Big fingers will find connecting the coiled cigar lighter-style power cable to the unit a challenge. The battery cover comes off way too easily, retained only by a few threads of a small slotted screw. If the external power cord becomes dislodged at either end, the unit switches to internal battery power without doing much other than a single beep to let you in on the secret. Rechargeable backup batteries can only be revived after removing them to put in an external charger. And, a tutorial that shows us mere mortals what the unit can do would be invaluable.

But when the EKP-IV quickly becomes a best friend on the flight deck. It greatly reduces cockpit workload by providing comprehensive flight data from a single source, communicating what you need to know right now. With a street price around $1500, the EKP-IV provides a lot of bang for the buck. True, it doesn't have some of the features that other, more expensive portable GPS systems do, but what it does do is done with style. +

The EKP-IV also stores the flight path tracks of previous flights. Here you can see a long base entry to 28 Right.

For more information, contact AvMap/Navigation at 800/363-2627. A direct link to the company's web site can be found at www.kitplanes.com.

Build Your Skills

Metal Part 9

You say pound, I say squeeze—let's explore the other side of setting rivets.

BY DAN CHECKOWAY

Keep poundin' those rivets! You may have seen this tag line slapped on the end of motivational e-mail messages on various online builder forums. The idea behind this saying is to convey that there really is a light at the end of the tunnel—that there will come a time when you have no more rivets left to set (ah, pound), and you'll be flying the plane you built with your own two hands. I love the notion, but I actually prefer a variation on the theme: Keep squeezin' those rivets! From my perspective, I would much rather squeeze rivets than shoot and buck them.

Photos: Marc Cook

Less expensive squeezers (top) can be more painful to use. See how stretched out your hands may need to be? It's difficult and tiring to produce much force like this. Better designed hand squeezers (above) require less hand stretching and enable you to produce more force comfortably.

In a way, we started you out with the more difficult techniques. This is most definitely subjective, and I'm positive that quite a few builders disagree with me on this, but I personally find squeezing to be the easiest and most straightforward method of squashing rivets. The advantages? First and foremost, you can achieve 100% perfect uniformity of shop heads. When shooting rivets—using the rivet gun, as we've been discussing—it's not necessarily difficult to achieve this uniformity, but it takes much more finesse and practice.

Without getting into too much detail on the tools or techniques just yet, suffice it to say that when squeezing, it's possible to adjust your tools in a "set-it-and-forget-it" mode, and they'll literally form perfect, identical shop heads right on down the line. The other advantage of squeezing is that it's *quiet!*

Can You Squeeze Them All?

If it's so quiet and easy, then why don't we squeeze every rivet on the plane? Recall our discussion on back riveting—it's a technique generally preferred over bucking rivets because it's so easy, relatively speaking. But just like there were limitations with back riveting, it's the same deal when it comes to squeezing rivets.

It's not a matter of access, but rather limitations that the tools impose.

Tools, Again!

And on that note, it's time to start yapping about tools again. Because you've probably already done some dimpling, you may already have been exposed to the same tools we'll be using to squeeze rivets. Despite the variety of designs, they serve the same purpose. The anatomy of a squeezer is basically a yoke, a plunger, and some mechanism to actuate the plunger. The yoke is a rigid piece of steel, usually shaped like a C. The yoke attaches to the body of the squeezer with bolts or pins, and the plunger pushes up into the jaws of the yoke through a hole in one side. The plunger is usually adjustable by virtue of being able to screw in or out. This allows you to fine-tune the resulting gap between the plunger and the top of the yoke when the squeezer is fully actuated.

Here's a longeron yoke with a cupped set on one side, and a flush set on the other. You can swap the sets around if that works better with the orientation of the rivet.

The plunger has a receptacle into which you can put a rivet set (or dimple die). On the opposite side of the yoke there is usually another hole (it depends on the style of yoke), in which you can place another rivet set (or complementary dimple die). If you're squeezing a universal-head rivet, you'll put a cupped set on one side and a flush set on the other. If you're squeezing a flush rivet, you'll put flush rivet sets on both sides.

Your Main Squeeze

Squeezers break down into two major categories, the first of which is hand squeezers, operated manually by hand. They all work in the same fashion, which is by using some sort of cam system or some other means of stepping up force to apply a significant amount of compression when the plunger is forced up against the opposite side of the yoke.

Despite those little rivets being made of a relatively soft aluminum alloy, it still takes hundreds or even thousands of pounds of compression to squash them. It's not like a pair of pliers, where there's a linear ratio between the force applied at the handle and at the jaws. Even if you eat your spinach, you're still going to need some help in the way of developing a mechanical advantage, and that's where

Here are two flush sets in a C yoke. Sets come in different thicknesses, which can be used to provide the yoke clearance over nutplates, other rivets, etc.

The adjustable set simply threads in and out of the squeezer. This lets you fine-tune the gap between sets, and it affects the dimensions of your shop heads.

The yoke: It attaches to the squeezer body with two bolts or pins, has a hole in the bottom for the plunger, and typically has a hole in the top for a set or dimple die.

There's no end to the variety of shapes and sizes of yokes. Here are two C yokes and a "thin-nose no-hole yoke" (upper right).

the size of your wallet—more so than the size of your forearms—comes into play.

Don't Be Cheap

The cheap hand squeezers are just that—cheap. They are awkward for one, because of the wide angle to which the handles open. Take your hand and curl your fingers and thumb in, and slowly make a fist. Where does your hand develop the most force? I don't know about yours, but mine starts kicking in when my thumb and fingers are around 3 inches apart, and the force I'm able to generate increases the tighter it gets. So if you're trying to use a hand squeezer that starts to develop its force when the handles are 6 inches or more apart, what good is that? You really get what you pay for here.

What makes more expensive hand squeezers worth the extra bucks? For one, they have been designed with these human factors in mind, and the geometry is much more advantageous for the average clenching fist. The basic premise is that the squeezer develops the most force when the levers are within grip range of normal hands. A little engineering goes a long way, and these wrist-friendly tools do cost more. But like anything else in the tool industry, it comes down to how much you're willing to pay to avoid pain. If I'm going to have to squeeze thousands of rivets, I want the experience to be a pleasant one. Seriously, you're spending tens of thousands of dollars building your show-winning airplane—what's another 50 bucks? Keep in mind that aircraft tools are "liquid," in that you can always sell them to another builder when you're done using them.

Pneumatic squeezers, from left to right: single piston, tandem piston and alligator squeezer. The tandem is capable of squeezing much larger rivets, but is often overkill.

Hold On, You're Not Done Buying Tools

OK, so I've got you all lubed up, your checkbook is handy, and you've bought into the mindset of saving pain by spending money on nicer tools. Good deal. Let's drop a few more C-notes! The other category of squeezer is the pneumatic squeezer, which is operated by air pressure. (I'm getting goosebumps as I write this...oops, I drooled a little.) Talk about being lazy while accomplishing a tremendous amount of work. When using a pneumatic squeezer, the only thing that might get sore is your poor little thumb, because it's going to have to pull that trigger over and over again. I joke, but using the pneumatic squeezer is an absolute pleasure. You literally just pull the trigger and the thing develops thousands of pounds of force with essentially zero effort on your part.

Pneumatic squeezers are expensive. They cost on the order of $400 and up. Sometimes you can find a good deal on a used one, but be careful—you may end up spending just as much having the tool rebuilt as you would just buying a brand new one. Many builders consider the pneumatic squeezer an unnecessary luxury, and they're certainly entitled to that opinion. I suggest you find another builder who has one of these pneumatic puppies and give it a try.

If you do spring for a pneumatic, make sure it's of the variety that takes the same style yoke as whatever hand squeezer you have. Some hand squeezers such as the Tatco brand, while very nice tools, use yokes with a proprietary attachment style that is not interchangeable with any other brand of squeezer. Most other varieties of hand squeezers and pneumatic squeezers accommodate the same style yoke. Keep this in mind when shopping for tools.

Some pneumatic squeezers come with a non-adjustable set. With this configuration, the way you adjust the gap is by using shims or washers between the set and the plunger. Some people swear by this method. Using a combination of AN960-10 (1/16-inch thick) and AN960-10L (1/32-inch thick) washers, you can tweak the gap until it's close. An alternative to doing this is to purchase an adjust-

Using a pneumatic squeezer only takes one hand, which frees up the other hand to stabilize the work. All you have to do is push the trigger with your thumb.

If you don't have an adjustable set, you can use washers to adjust the gap. The author used washers for about 10 minutes, then sprung for the adjustable set!

able set, which allows you to thread it in and out and have infinite control over the gap. In my opinion, this is easier, faster and more accurate than using shims.

To make matters more confusing, pneumatic squeezers aren't all created alike. You'll find single-piston, tandem-piston and alligator varieties. The tandem is capable of generating significantly more compression force, but costs more and is larger and heavier. The tandem squeezer is pretty much overkill for the needs that arise when building most kit aircraft. It's unlikely that you'll need to squeeze any rivets larger than $1/8$-inch (diameter), which are easily squashed using single-piston designs. The alligator squeezer has its advantages due to the geometry of the jaws, which can sometimes reach around larger flanges more easily than can yoke-style squeezers. Even so, I still consider the alligator squeezer less versatile than standard squeezers and yokes.

Speaking of yokes, there are all sorts of shapes and sizes available. Probably the most common and versatile would be the 3-inch C yoke. It can be used for dimpling and squeezing rivets along flanges and edges. You'll find C yokes in several sizes ranging from about 1-inch depth all the way up to 6 inches and maybe deeper. The limiting factor of yoke depths is stiffness—ideally the yoke must not flex when under stress.

A nice addition to any arsenal of yokes is the so-called longeron yoke. It gets its name due to the fact that it can reach around wide flanges, such as those of a longeron. This yoke is usually not as deep as most C yokes, but you can use it in some more challenging spots.

A third variety is a modified C yoke that doesn't take a set or die on the top. It tapers down very thin in order to reach inside tight spaces such as trailing edges of control surface ribs. It is called the "thin-nose no-hole" yoke. Because it doesn't have a hole in the top and doesn't accommodate a rivet set, the inside top surface is flat. This is a pretty useful puppy to have when riveting elevators and ailerons and that sort of thing. It's by no means a necessity, but it may make the difference between having to use a pop rivet and a solid rivet in some cases.

This is a close-up of the "thin-nose no-hole" yoke. You can see there's no hole at the top for a set. The top surface itself is flat and acts as the flush rivet set.

How many yokes does the average builder need? Technically the answer is probably zero, because these squeezers are in essence a luxury. Yokes typically cost between $100 and $150 each! But again it comes down to how much money you are willing to spend in order to avoid pain, and how smooth you want the finished product to come out. I personally recommend having each of the three yokes mentioned above.

Generally, yokes are interchangeable from squeezer to squeezer—and that applies to hand and pneumatic squeezers alike. Just pull the pins (or bolts) and swap yokes.

Using a hand squeezer is satisfying work, but it's tiring at best. If you're on a tight budget, get used to this pain. Otherwise, the pneumatic squeezer is worth its weight in gold.

Put Those Tools To Use

Enough babble about the tools. Let's talk about how to use them effectively. When using a squeezer on rivets, there are really only two cardinal rules. (1) Always pull/push against the manufactured head to keep the rivet firmly seated in place while you squeeze it. (2) Always keep the squeezer aligned with the rivet. If you follow those rules, you are pretty much guaranteed success.

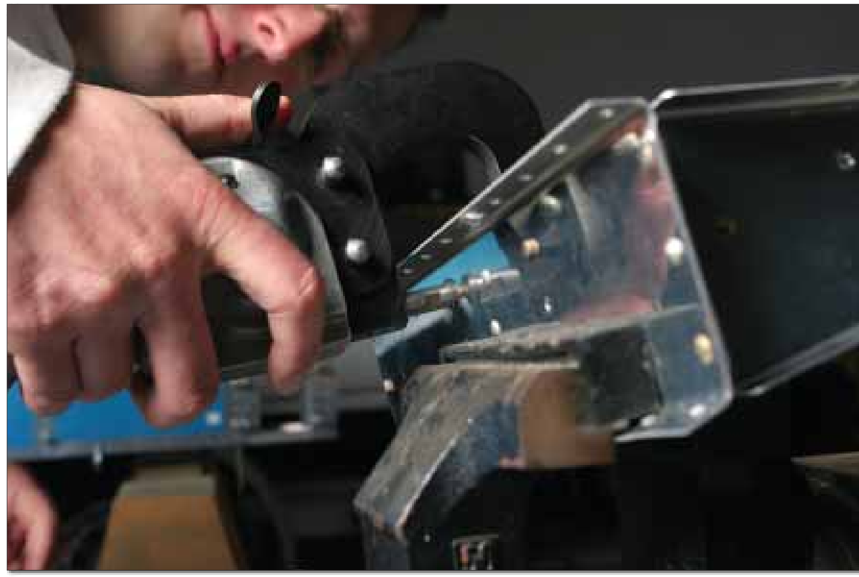
As we discussed with respect to shooting and bucking rivets, it's important that the shooter apply more pressure on the rivet than the bucker. The same applies when squeezing, and it means you need to hold the squeezer in such a way that the manufactured head is pressed up against the work. If you get sloppy, it's really easy to mess up the rivet and allow a gap under the manufactured head. This is no good—the rivet will need to be drilled out. Always apply a good amount of force against the rivet as you squeeze it. Whether that means pulling or pushing depends on the orientation of the squeezer and the sets (cupped or flush), but the rule applies regardless. Usually it's easiest if the work itself is held in a vise or clamped to a bench or something, so you can use both hands on

Depending on how the flange is oriented, sometimes you can use a C yoke in these cases (top). It depends on whether or not you have space for the squeezer on the flange side. Here's the opposite orientation (above). You can see the standard C yoke doesn't fit the bill. The flange interferes with the yoke, preventing the set from contacting the rivet.

the squeezer to keep it stable and apply force in the right direction as you actuate it.

The alignment thing often plagues new builders. It's easy to misjudge the angle at which you're holding the squeezer, and the result of misalignment will almost always be a tipped rivet, or at best a shop head that is cocked to one side. If your shop heads aren't ending up

Thus the longeron yoke, which can reach around flanges like this without any interference. A combination of a C yoke and longeron yoke will pretty much serve most purposes.



Keep the squeezer aligned with the rivet and square to the work. This ensures that the shop head won't tip, and that you won't have any gap under the manufactured head.

parallel to the work, then you are most likely introducing some misalignment when holding the squeezer.

Rules For Pneumatic Squeezers

When using a pneumatic squeezer, things get quite a bit easier. You can almost always hold the squeezer with just one hand, freeing up the other hand to stabilize the work. And since all you have to do is move your thumb to pull the trigger, it's much easier to keep the tool stable and aligned. That's not to say that the pneumatic squeezer doesn't have its share of pitfalls.

First of all, you need to be aware of the safety risks inherent in using a pneumatic squeezer. This sucker produces thousands of pounds of compression with little provocation, which can absolutely obliterate your fingers or anything that may get caught between the jaws. You must be extremely careful when pulling that trigger. Don't rush, and don't get careless!

It's easy to over-squeeze a rivet if you don't have the set adjusted properly. I often get asked by new builders how to initially set up the adjustment when squeezing a rivet. The best answer I can give you is that you should be conservative on that first adjustment—it's always best to under squeeze the rivet and then have to tighten up the adjustment bit by bit to creep up on the proper setting. Remember from our earlier discussions that the finished length of a rivet is the grip length plus half the diameter. If you know the thickness of the layers you're riveting, you should be able to come up with an approximate measurement to shoot for between the rivet sets. Once you set it where you want it, it shouldn't require any readjustment. Cruise right on down the line of rivets, and they should all come out the same.

Sideways Is Not the Right Way

Another gotcha when using the pneumatic squeezer actually applies to the hand squeezer as well, and it comes into play when squeezing flush rivets. Those flush sets are pretty smooth and can slide around on the work a bit as you're positioning the squeezer. It's all too easy to let the flush set slip sideways a little before squeezing the rivet. If you're using a relatively narrow flush set, it might miss the rivet entirely. Worse, it might only partially cover the shank, in which case the shop head is going to be a mess. It takes some diligence, particularly with the pneumatic squeezer, to keep the flush set in place centered over the rivet as you start to squeeze it. With universal head rivets, this isn't as much of a problem, but you still could inadvertently position the cupped set off center a bit—which can result in a smile on the manufactured head, and probably a tipped shop head.

I have been around several builders who don't seem to grasp the concept of properly adjusting squeezers to achieve uniformity. They apparently don't realize that it's easiest to adjust the set for full actuation. In other words, they have the squeezer adjusted too tight, requiring them to stop before it is fully actuated—otherwise the rivet would be over-squeezed. I watch these guys do it this way, and they always have to guess when the rivet has been set properly. This makes no sense to me. I recommend adjusting the squeezer so that the rivet is perfectly set when the squeezer reaches the end of its range of travel. This applies to the hand squeezer as well as the pneumatic. That way, there is zero guesswork. Every rivet will come out the same as the last one. This may sound obvious but believe me, I've seen lots of people who don't seem to understand this simple concept! Always use the tools to your advantage.

Here's where that "thin-nose no-hole" yoke comes in handy. Any other yoke style wouldn't fit in between those flanges at the trailing edge. The thin nose *just* fits.

With a combination of yokes—and typically having the option of coming at the work from two possible orientations—you can usually come up with a way to use a squeezer when riveting structures (i.e. ribs to spars) and on most edge locations on the exterior surfaces. Nevertheless, there will be scenarios when you just can't figure out a way to finagle a squeezer in there. No sweat...you can always fall back on shooting and bucking. Maybe you'll end up preferring the shooting/bucking method over squeezing anyway. Regardless, at this point, I think we've given you a pretty solid foundation for the different types of riveting you're likely to do on your project. You'll get lots of practice using all of these methods, and you'll undoubtedly develop preferences for the techniques you like best.

Ouch! The set must have slid off the rivet head on the other side, because the set on this side only hit part of the rivet. Pretty ugly, and this needs to be drilled out for sure!

With so many different tools and methods at your disposal, you're bound to make a mistake or two as you learn. Next month we'll focus on how to fix those mistakes—in particular, the inevitable act of drilling out badly set rivets. Until then, keep squeezin' those rivets! ✈

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SPORTPLANES™ MARKETPLACE

WIND TUNNEL

BY BARNABY WAINFAN

Getting the (Aero) *Bends*

In the last few months, we have examined some of the effects of aeroelastic distortion as flight loads act on the airframe. We have covered the effects of local surface deflections and the way aeroelastic twisting affects the structure of the wing and influences roll control. Now we turn our attention to the effects of air-load-induced bending.

The wing generates aerodynamic lift that supports the airplane in flight. This lift is distributed along the span, typically in a nearly elliptical fashion. The centroid of the lift is usually inboard of the midpoint of the span—outboard one-third of the way from the root to the tip. The lift causes bending moments along the span of the wing. Because the wing structure is not perfectly rigid, the wing bends as the lift acts on it.

Bending Effects

All wings bend under load and some actually bend quite a bit. The wingtips on large jet transports can move up and down more than 20 feet in flight. While some wing bending is acceptable, it can also cause problems that may determine how much bending can be tolerated.

As the wings bend under air load, the effective dihedral angle changes. This in turn changes the lateral and directional stability of the airplane. The amount a wing bends is proportional to the lift generated. Accordingly, the wing will bend more when the airplane is in a pull-up or turn. If the wing is too flexible, there may be a large change in the lateral/directional flying qualities as the plane maneuvers. This may cause the pilot difficulty in keeping turns coordinated or, in extreme cases, could make the airplane difficult to control in certain flight conditions.

Control Surface Binding

When the wing bends, the control surfaces (flaps and ailerons) bend with the wing. This causes the hinge lines to become curved, which can cause the control surface to bind. There are several solutions to this problem. One is to use discrete floating hinges that can self-align to relieve the binding loads. Another is to segment the control surface, dividing it into several shorter surfaces. While all of the surfaces still bend, the total bending along the length of the hinge line of the shorter surfaces is smaller, greatly reducing the tendency to bind.

Mechanical control linkage elements (cables or push-pulls) act in a straight line. As a wing bends, the length between bellcranks or control horns in the wing can change. This will cause cables to slacken or get tighter, put loads on push-pulls and result in uncommanded control deflections or slack cables that cannot move the controls. Wing bending can also cause spanwise control linkages to foul on structure, particularly where cables or tubes pass through ribs or other structure.

Barnaby Wainfan's day job is in aerodynamic design for Northrop Grumman, where he serves as Technical Fellow for Aerodynamics Design and Analysis. 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.

Shape Effects and Thickness

The deflected shape of the wing depends on several factors. For cantilever wings, the three most important geometric factors determining how much the wing bends—and the shape of the bending—are aspect ratio, taper and wing thickness.

Making a wing thicker makes it stiffer. As the wing gets thicker, the spar caps move away from the neutral axis of the spar. This gives the spar caps more arm to act on in order to resist the bending moment caused by the lift loads. For an I-beam spar with constant cross-section spar caps, the bending stiffness is proportional to the square of the vertical height of the beam. Accordingly, a relatively small change in the thickness of a wing can have a relatively large effect on its bending stiffness.

High-performance sailplanes encounter severe bending loads on their long, slender wings.

Aspect Ratio

For any cantilever beam, the longer and thinner it is, the more flexible it becomes. At a constant wing area, increasing aspect ratio makes the wing longer and its chord shorter. The shorter chord makes the wing thinner if we keep the airfoil the same. Accordingly, aspect ratio has a powerful effect on the bending stiffness of a wing. The effect is nonlinear because the wing gets both longer and thinner as aspect ratio increases. The greater span moves the centroid of the lift load outboard, which increases the bending moment on the wing, and the reduced thickness decreases the inherent bending stiffness of the spar that must resist this higher moment.

Talk About Taper

Tapering a wing improves its bending stiffness, making the wing root chord larger and the tip chord smaller. This increases the thickness of the inboard portion of the wing where the bending moments are highest and makes the wing thinner outboard where the moments are lower. In so doing, the taper makes more efficient use of the wing spar cap bending material and reduces the overall wing deflections under a given load.

Tapering the wing also changes the air loads in a way that reduces the total bending moment on the wing because it shifts the centroid of the lift load inboard. This reduces the lever arm of the lift load on the wing root and reduces the total wing root bending moment.

"Taper makes more efficient use of the wing spar cap bending material and reduces the overall wing deflections under a given load."

When compared to a constant-chord wing, the tapered wing thus has the advantage of having a thicker spar at the root that is called upon to withstand a lower bending moment.

Structural Stiffness and Materials

When designing a wing structure, the designer must take both strength and stiffness into account. It is possible to have a structure that is strong enough to take the air loads—in the sense that the loads will not impose any stresses that exceed the yield strength of the materials in the structure—that will still be too flexible. If the structure is strong enough but not stiff enough, the wing will flex unacceptably under load.

The structure's materials have a strong influence on how much the structure will bend under load. Structural materials are characterized by two important physical properties. The yield stress is the stress level at which the material will start to fail under load. The modulus of elasticity is a measure of the effective spring constant of the material. It is an indicator of how much the material will stretch or contract when it is loaded. The higher the modulus of elasticity, the less the material will deform under a specific load. In the design of a structure, the yield stress of the load-bearing material defines how thick the structural members must be in order to carry the load. Once the structure is sized so that the stress level in the load-bearing elements is below the yield stress of the material, the modulus of elasticity of the material determines how much the structure will flex when it is loaded.

Strong and Stiff—Finding the Right Balance

When we choose a material for a wing structure, we want a proper mix of strength and stiffness. The optimum mix depends on the geometric characteristics of the wing. If the structure is inherently stiff—as would be the case for a relatively thick, short-span wing—strength tends to dominate. Because the structure is inherently stiff, it does not tend to deflect much under load. In such a case, the size (and weight) of the spar caps is determined primarily by the yield stress of the material.

For wings that are thin, or of unusually high aspect ratio, stiffness becomes more important. Even after the spar caps are strong enough to take the loads without failing, the wing is likely to be too limber to take flight loads without bending excessively. When a structure is sized by stiffness rather than strength, the designer has two design approaches available. The first is to simply make the spars heavier by adding more material until the wing is stiff enough to be acceptable. This is often adequate, but it tends to make the airplane heavy, which may negate the aerodynamic advantages of the specific wing shape.

The second approach is to make the structure out of stiffer material with a higher modulus of elasticity. This is one of the primary reasons to use carbon fiber in wing spars. Carbon fiber has a much higher modulus of elasticity than any metal used for wing structure. It is roughly three times as stiff as aircraft-grade aluminum, so for two wings having the same geometry and the same spar-cap cross sections, the wing with the carbon spar caps will bend about one third as much as the aluminum wing.

Other composite materials might not be as stiff as carbon. Unidirectional fiberglass composites have a modulus of elasticity very close to that of aluminum. Early composite airplanes had glass fiber structures, and accordingly were no stiffer than their metal predecessors. Some early composite homebuilts that had high-aspect-ratio wings had spar caps that were sized to give acceptable bending stiffness because a wing designed purely for acceptable strength would bend excessively. These airplanes had wings that were considerably overbuilt from a strength point of view. On one relatively popular design, making the wing spar heavy enough to make the wing stiff enough resulted in a spar that could carry a 16-G load without failing. While this resulted in a safe, strong, airplane it also meant that the wing was considerably overweight from a strength point of view. Newer, high-modulus materials make it possible to do a more balanced design.

Stiffer materials also allow designers to make more extreme wing geometries work. Good examples of this are the extremely high-aspect-ratio wings found on high-performance sailplanes and on high-altitude aircraft such as the Global Hawk UAV. In some cases the aspect ratio of these wings is above 30. Even with the best carbon-fiber wing spars, these wings are flexible and bend quite a bit under load. Without modern high-modulus materials it would be impossible to build wings like this at any acceptable weight. +

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BY TIM KERN

Guide Your Valves *Carefully*

Your engine's compression score may someday be below par. That sorry state of affairs could result from a number of causes—advanced age, too much activity, too *little* activity, worn parts or broken parts. If your engine is like most, the leakage out of the combustion chamber will be the result of rings failing to seal the piston to the bore or from a valve that's failed to seal against its seat. (Yes, you could also have a crack in the head. Let's hope not.) It's valve leakage that can cause more problems than a low compression reading. If left untended, the leaking valve won't just compromise compression, it can break off—all of the head or just a part of it—and allow bits and pieces to float around the engine, contaminating the oil system, tearing up the bearings and just generally causing mayhem. You want to avoid this problem if you can.

Valves and Guides: Living in a Harsh Environment

The familiar poppet valve must seal tightly against the interior of the combustion chamber yet must open quickly and reliably to allow the air/fuel mixture in and exhaust out. It's not an easy job for both valves. Experience shows that the intake valves in air-cooled aircraft engines typically lead long and happy lives; that they run comparatively cool is a big part of it. (Field experience shows that Continental's O-200s and O-300s have some intake-valve distress, but few other popular aviation engines do.)

Not so with the exhaust valves, which are subject to blowtorch-like temperatures. All components in the valvetrain must be working properly for the exhaust valve to have a chance of survival; particularly, the seat must provide a solid, uniform seal for the valve head (and it cannot be off center so that the valve cocks ever so slightly before it takes a full seat), and the guide must direct the valve into position accurately.

The arrow aims at the exhaust guide in a parallel-valve Lycoming head. (Actually, this is an ECI part.) It's a hard life in there, with the guide and valve stem facing high temperatures and corrosive post-combustion effluvia.

Guides look like simple tubes, and they are, but these beauties line up all the things that make your engine work. They point the valves in the right direction; they align the valve springs; and they allow the valves to operate smoothly, while (along with the valve-stem seals) keeping the lubricating oil from seeping into the combustion chamber. Even as it does all that, the valve guide receives virtually no attention between rebuilds and is expected to continue doing its thing with scarcely a second thought from pilots.

Elements of Wear

Valve guides wear for a number of reasons, the most common of which has to do with byproducts of combustion that get between the valve stem and the guide. Anything that increases such byproducts or makes them stickier—such as running mineral oil or burning leaded gasoline—will generally increase wear. High-lead gas can be destructive: see Lycoming's Service Bulletin 404, "Exhaust Valve Inspection (High Lead Fuel Operation)," for the details. (Sadly, a copy is not available at Lycoming's web site. You'll need to wrestle up a hard copy.)

Intake guides are commonly made of a bronze alloy, which is softer than the steel of the valve stem. For the exhaust side, guides used to be bronze as well but for Lycomings the current specification is a nickel-based steel alloy called ni-resist. These are hard guides and require a harder valve; the current configuration is a nimonic alloy valve. The bottom line: Guides are designed to wear, sacrificing themselves to prolong the lives of the more sophisticated valves.

Lycoming engines, particularly, seem prone to lead buildup on the exhaust valve stem, a characteristic that prompted the company to issue SB404, particularly applicable to low-compression 320- and 540-series engines. Leaded gasoline contains tetraethyl lead, and a lot of that lead is left behind on the valve stems. When a small deposit builds up, it merely restricts some flow, and the effect is not often even noticeable; but as the lead deposits continue to build, they can find their way into the clearance between the guide and the valve stem, causing the valve to stick.

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

Photos: Marc Cook

ENGINE BEAT

Morning Sickness

Engines can't get pregnant, but those suffering from incipient valve sticking often show a familiar symptom: They feel bad in the morning. If your engine is noticeably rocky on the first start of the day—and you've eliminated the usual culprits, including incorrect idle mixture and ignition—chances are a valve is sticking slightly. If the valve sticks open even a little, compression—and power—will be severely reduced. When this happens in flight, you will know it.

As time goes on, the partially open valve will burn away, crack or even disintegrate. If the valve sticks closed, you can do severe damage to your rocker arms, tappets, pushrods and cam. (It's not exactly good for the valvetrain if the valve sticks open, either.) In some engines, a stuck-open valve can contact the piston, which will surely rip off a piece and send it on the merry-go-round to tear up the rest of the engine.

Valves Seem Loose, Even When New

The maximum clearance between valve stem and guide seems like a healthy amount (typically .018-inch to .020-inch, but as little as .013-inch in some Lycoming engines), because as the engine runs, things snug up. The valve stem itself expands a little; the guide expands, pushing both into the inside diameter (ID) and outward against the head. The head itself expands more than the valve guide and tightens around it. What seems like a lot of clearance quickly becomes "just enough." Add to all those factors the uneven distribution of heat along the valve, stem and guide, and the originally simple problem becomes quite complex. In this case, a simple solution works: there is plenty of clearance between the valve stem and guide ID when the engine is assembled.

Lead salts collect on the valve head and can work their way up into the guide. Wear rates then shoot for the moon.

But...

Because there is a relatively large clearance between valve stem and guide, wear items (dirt, lead byproducts and carbon) get into the mechanism, and unless they are constantly flushed out by oil or blown off by the gaseous stream going by as the engine runs, they create wear. Although valve-stem diameter is easy to measure, measurement of the inside diameter of a valve guide is not. Sure, when it's new there's little trouble, but guides tend to wear oblong at the ends. The middle of the guide is typically the least-worn area, leaving the looser ends to allow the valve to rock in the guide. Because the valves are so much harder than the guides, it is unlikely that a valve will be the culprit in this scenario. Valves usually need replacement because of wear, burning, lead buildup or corrosion at the working end, down by the valve seat. Less often, the end of the stem, where the rocker arm makes contact, will get worn; some repairmen merely grind this area flat and smooth, but it's a short-term, off-label fix. (Sodium-filled valves, used in many Lycoming applications, have separate rotator cups between the rocker-arm tip and the stem.)

Because it is impractical to mass-produce valve guides that will start life with an ID that is larger in the middle than at the ends, valve guides are pressed into the heads and then reamed to size, yielding a bore that is consistent from one end to the other, in the finished assembly. Everything is perfect from then until the engine runs, when thermal expansion, pressure and friction start changing every component's dimensions.

Experienced mechanics can very accurately judge correct valve stem clearance by rocking the valves with their fingers, once the valve springs are removed. They know when there is too much rock, and they replace the guides. It's art rather than science, though, and the best way to learn this technique is from a patient mechanic—and lots of practice.

How Can We Tell?

You don't have to learn the magic. Instead, turn to Lycoming's Service Bulletin 388C, which outlines a procedure for checking valve-guide clearances with the cylinder on the engine. Lycoming recommends the test every 400 hours (300 for helicopters) or sooner if valve sticking is suspected. This SB was tagged as mandatory by Lycoming for engines using an older-style valve guide. (The company updated its engines to a "Hi-Chrome" guide in the late 1990s that eliminated the SB388C inspection.) Nevertheless, the inspection is useful to determine if your guides are holding spec. Moreover, if you have an older or rebuilt engine with the previous version of the guides, it's good practice to follow the SB388C inspection procedure.

What Can You Do?

Believe it or not, good piloting techniques along with proper maintenance procedures can help reduce valve sticking. Running excessively rich at low power will drop more deposits on the valves than is necessary. Running the engine very hot will put stress on the valves and guides, whose temperatures track CHTs not just EGTs. (According to a NACA study, exhaust valves run hottest at around 40° rich of peak EGT.) Keep up with your oil-change intervals as well. Be aware of your engine's behavior on the first start of the day. If it hiccups, shudders and acts too surly, think hard about the guide inspection. It's cheaper now than it will be if you ignore the symptoms and then a valve sticks or breaks. Trust us on that one. ✈


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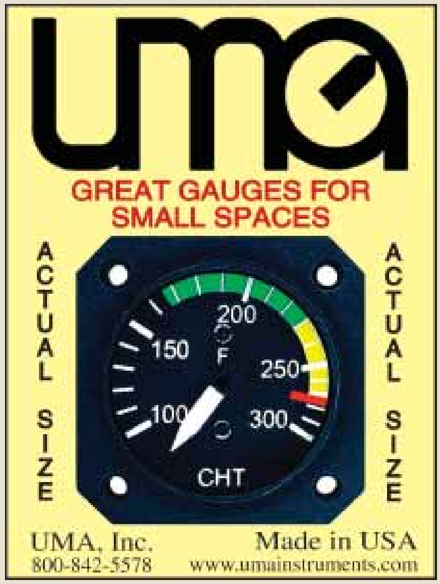
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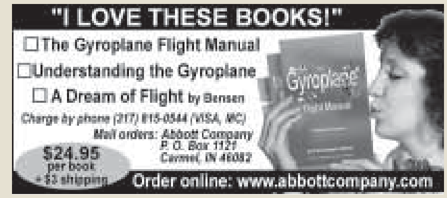
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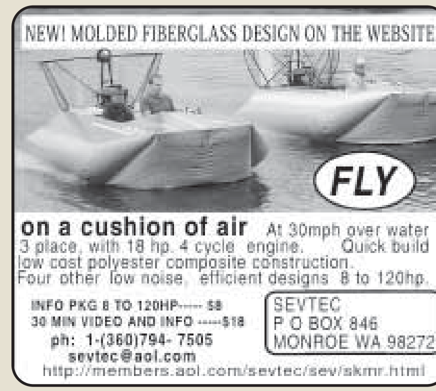
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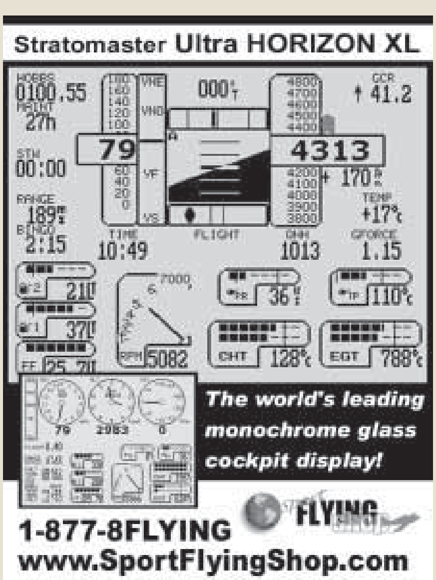
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LIGHT STUFF

BY DAN JOHNSON

For This Veteran Columnist, *A Farewell*

Part of the job entails photo shoot flying, too. Here, Dan comes in nice and close with the Quicksilver GT 400 and smiles big for the camera.

This column, conceived with reference to the still-popular 1983 astronaut movie, "The Right Stuff," (and Tom Wolfe's book, of course) has run steadily since 1992. The focus has always been on the lighter end of the homebuilt spectrum, and I've covered a large variety of Part 103 ultralights and hang gliders. While writing about gyros, helicopters, powered parachutes, emergency parachutes, paragliders and many industry events, I've made it my priority to stay true to the nature of the column and keep focus on developments in that light end.

It has been a most interesting run for 14 years, teaching me as much as anyone while I uncovered details about all sorts of aircraft that captivated my attention. I wouldn't trade the act of creating those 150+ columns for anything.

But, I will give up the run. This is farewell for "Light Stuff." I've chosen to retire from my position as writer of this column. Over the years, I've heard from hundreds of KITPLANES® readers. You've been most kind. It has been a pleasure serving you. It feels right to leave the stage while still popular.

I plan to continue a significant writing schedule, but I've chosen to tighten my focus. My special attention in light aviation has been flying new aircraft and reporting on them. My full-length pilot reports have been published in more than 600 articles in nine magazines covering more than 300 aircraft that I've had the great delight to fly. Well, most of them were a delight; the others created delightful stories!

You can count on many more articles from me in KITPLANES® and other titles. And many past issues of "Light Stuff" are permanently available via my web site or through the magazine's customer service department.

To close out my run, I'll provide a quick review of some significant changes that occurred over the 14-year period. Though 1992 may not seem so long ago, I think you'll be impressed to hear what changed in just under a decade and a half.

Everyman's Airplane

Ultralights—and FAR Part 103, which created them—were only 10 years old when this column debuted. The industry and community had convinced the FAA that two seaters were needed to conduct proper training, but they were only permitted under an exemption to the rule. Quicksilver's wide-open-cockpit MX series dominated flight schools with more than half the market. Nearly all ultralights remained aluminum-tube airframes with sewn Dacron wings and tail coverings, though some had started to add dope-and-fabric coverings. Nose pods were starting to grow aft into full enclosures.

Dan Johnson has reviewed more than 300 aircraft in his career as a leading flight reporter of sport airplanes. A 5000-hour commercial/instrument/multi-engine pilot, Dan's current focus is on Light-Sport Aircraft, ultralights, homebuilts and gliders. In 2001, he was the recipient of the Spirit of Flight Award from the Society of Experimental Test Pilots. Visit his web site at www.bydanjohnson.com.

The author, in earlier days. As an aviation writer, Dan's first love is flight reports, so he's spent many hours at the controls of various ultralights during his years writing "Light Stuff."

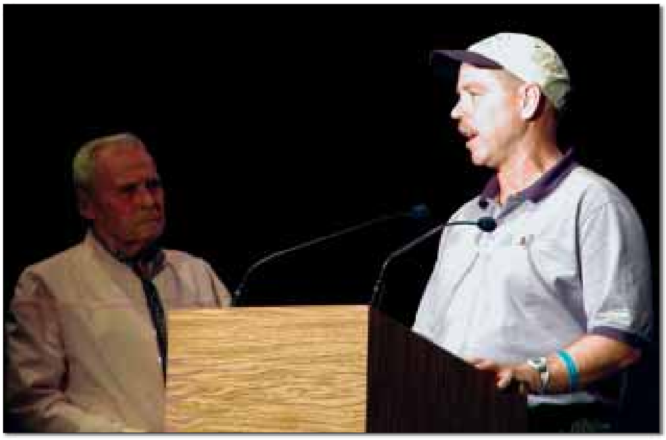
Instruments were all steam gauges in 1992, though the hang gliding community had embraced electronic devices to help them find thermals. The Garmin brand was only three years old; most aviators had never heard the name and didn't know what a "glass panel" was. The first portable GPS units with moving maps arrived in 1993; ultralight and hang glider pilot leaped on such technology, which required little power and had low prices.

Photos: Dan Johnson

Oh, those prices. You could buy any number of ultralight kits for less than $10,000. Tennessee-based TEAM Aircraft had several models under $4000 (without powerplants). Fourteen years later, those numbers seem absurd with some LSAs exceeding $100,000. Fortunately, we still have many choices from familiar companies in which you can get airborne with a two-stroke engine for $25,000 or less.

Besides the ubiquitous Quicksilvers, other big names were Quad City Challenger, CGS Hawk, RANS and Kolb. All remain active today, I'm happy to report. Yet now the spotlight seems turned to sleek carbon-fiber four-stroke LSA flying far beyond the speeds of ultralights.

Just before "Light Stuff" started, the Rotax 582 began a long, successful run offering more power than the still-popular Rotax 503. You could buy a half-VW engine but otherwise, two-stroke powerplants were king. The 100-hp Rotax 912S that powers many carbon-fiber and all-metal LSAs today was still six years from introduction when the column began. The Jabiru aircraft was introduced in 1992, and the company released its first engine the following year; no one in America knew the powerplant, yet today they have achieved a significant market penetration in the homebuilt and LSA worlds.



Dan received the Spirit of Flight Award from the Society of Experimental Test Pilots in 2001. The presenter (left) was SETP member, former astronaut and California state senator Pete Conrad.

Technological Evolutions

In 1992, we were still three years from the "official" beginning of the World Wide Web. Oh, we had the Internet, but it was pictureless, and we had no aviation web sites where pilots can now find a vast storehouse of information and services plus thousands of archived articles.

Some of the benefits of the job—cool trips, cool airplanes! Here, Dan flies a float-equipped AirBorne trike near Anchorage, Alaska.

E-mail was rarely used in 1992. How could I possibly have submitted an article without e-mail? Well, I placed them on a floppy disk and sent it via postal envelope to the KITPLANES® office. Snail mail? How *ancient*! It would be years before I had electronic images to submit to the magazine. Digital cameras for popular use were still some eight years in the future when "Light Stuff" started.

Even in the later '90s, most pilots didn't have high-speed Internet service, technology that would later allow pilots to download all manner of useful information and quickly update their increasingly electronic cockpits.

But balancing these improvements are restrictive rules following the events of September 11, 2001. Now TFRs are part of daily flying life, and ADIZs are a new battleground. In 1992, airspace still featured areas called TCAs and Airport Traffic Areas instead of today's A-B-C airspace.

All New FAA Oversight

Some are saying the Sport Pilot/Light Sport Aircraft rule is the most exciting and sweeping change FAA has *ever* made. While hard to quantify, it is true that the FAA has never done anything like this.

Industry writes it own certification standards. Yes, the FAA is involved in their development, but only as a participant. Of course, they must accept and sign off on the standards as released, but it is not their mission to write certification regulations.

Factories producing fully built aircraft that can be used for commercial purposes like training and rental do not need to obtain a production certificate. That's because the new rule asks Designated Airworthiness Representatives, non-FAA civilians, to do the final certification inspection.

Sport Pilots, once certificated, can add new skills and need only obtain a logbook endorsement from their instructor. And no aviation medical is required; a driver's license serves as your proof of medical fitness.

All of this grew from the ultralight movement of the '80s and '90s.

Exciting Times Ahead!

Yes, it's been an interesting 14 years. Change is coming faster and faster. I'll do my best to keep you informed on new aircraft, and KITPLANES® will continue to provide great content month after month.

So long, Light Stuff...

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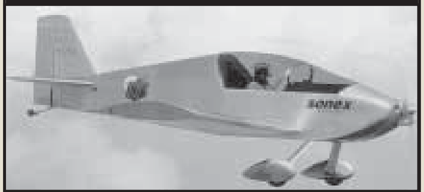

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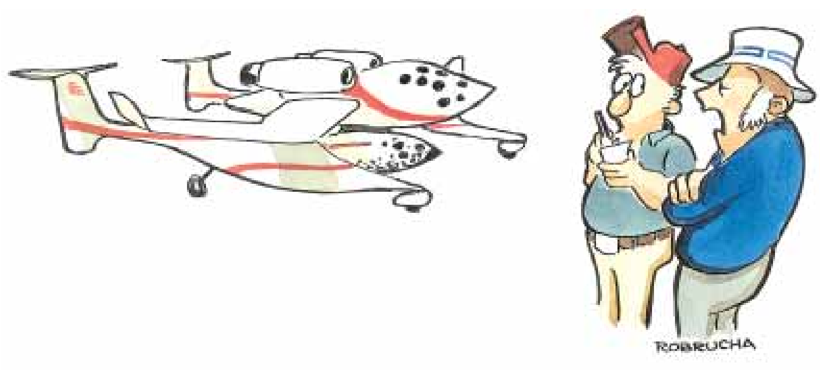

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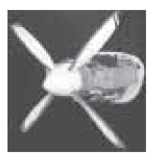

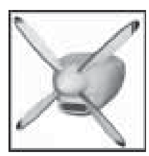

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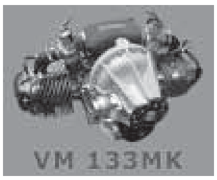

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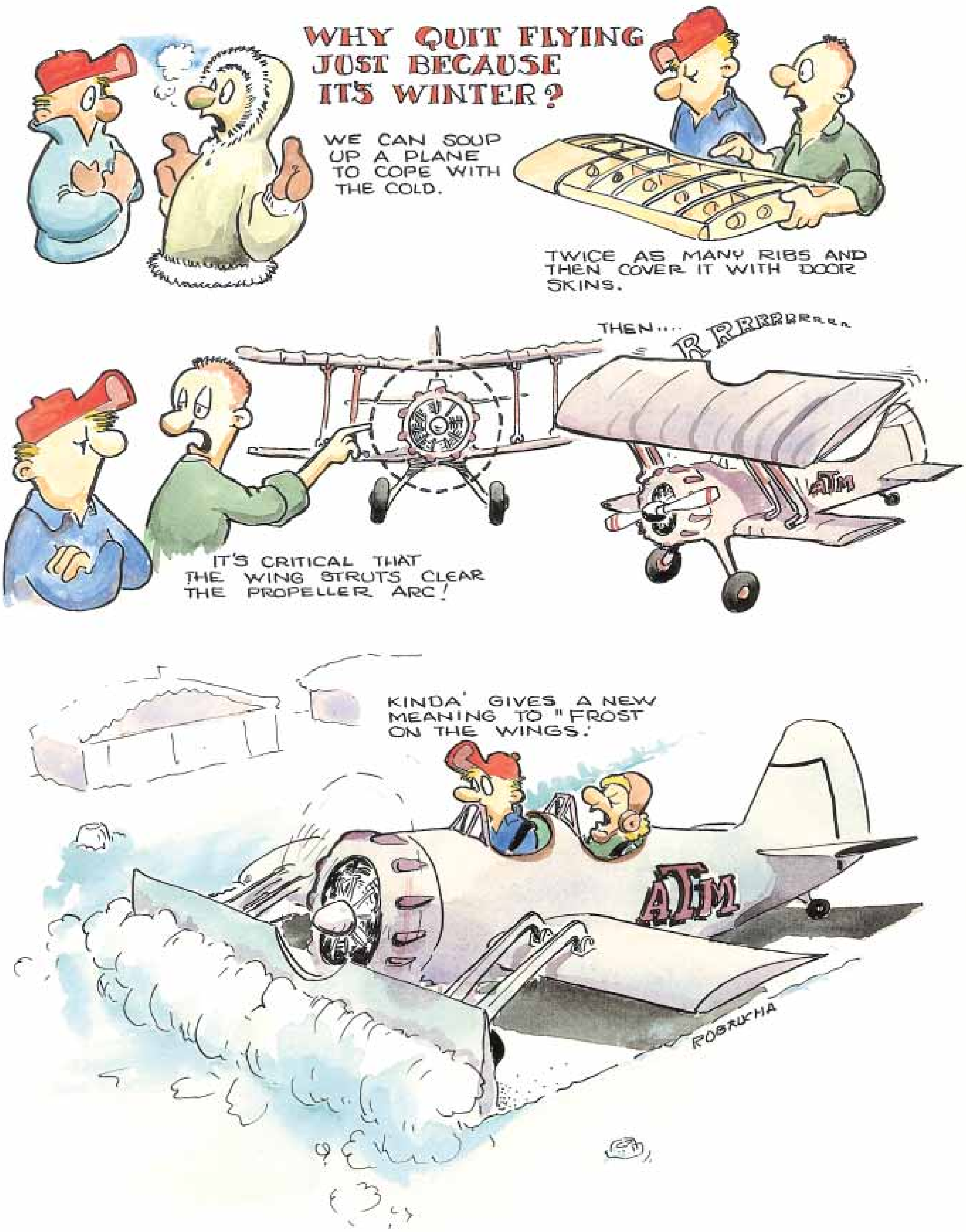
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