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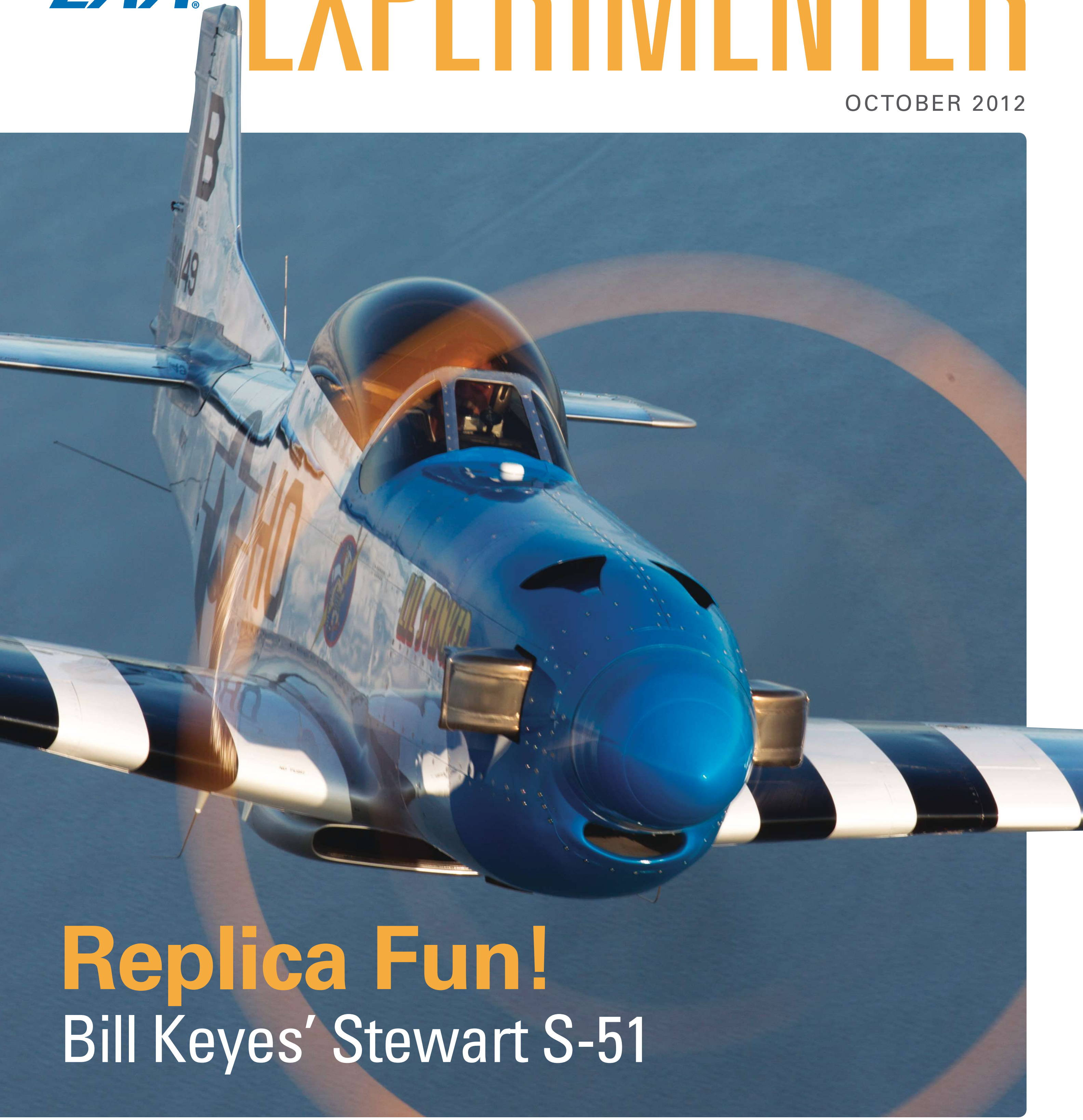
EAA EXPERIMENTER

OCTOBER 2012



Replica Fun!

Bill Keyes' Stewart S-51

» 2012 Homebuilt Award Winner
The Aerochia LT-1

» Baffling...
It doesn't have to be

Checking In
Flying new-to-you airplanes

By Chad Jensen

I've had the opportunity to fly a number of airplanes since I've been on staff at EAA, and I'm quite pleased with the amount of flying that I'm able to do here.

When new-to-me airplanes become available to fly, I use the checkout training system to transition to that airplane. The term "checking out" should really be "checking in." I've checked in to six different experimental airplanes over the last year—the two Glastars at Pioneer, Sonex tri-gear, Onex tri-gear, RV-6A, and the Wag Aero Cuby.

Checking in to an experimental amateur-built (E-AB) airplane (airplane-AB) is something no one should take lightly. Even if you have previous time in a similar type (I built and flew my RV-7 but still took instruction in the RV-6A), they all fly a little differently, and they all have different panels and systems.

I did my tailwheel endorsement in 2007 in a J-3. The Cuby is the experimental version of the J-3, so it's no big deal, right? Well, the J-3 had a 65-hp engine; the Cuby has an 85-hp engine on it. Not a big difference, but they are different, and the Cuby does fly a little differently than the J-3. I was pleased with my training in the Cuby to get me ready to fly it regularly; it's the airplane of choice for me!
A check-in at Pioneer Airport has as much to do with the airport environment as it does the airplane. I went through the ground school and then started training at the airport in the tri-gear Glastar. While I was signed off to fly the tailwheel Glastar solo, I did not complete my training to fly Young Eagles from the airport in that airplane. Why one Glastar, and not the other? They are different. Not just in the case of where the little wheel resides on the airplane, but they fly differently. The pitot-static system is slightly different in each airplane, the speeds are different in the pattern, and the list goes on. So close, yet different.

The folks at Sonex have allowed me to fly a couple of their airplanes, and it has been a wonderful experience.

Flying the tri-gear airplanes first allowed me to learn to fly the airplanes without having to worry much about winds during the takeoff and landing phases of flight. I haven't yet flown the taildragger Sonex or Onex, but I wouldn't even think of doing so without training.

My challenge to all of you who check in to new-to-you airplanes is to get the proper transition training from a qualified instructor. A focus at EAA is safety of the E-AB segment of aviation. We are under the gun from the NTSB to improve our record. EAA's Safety Initiative is a big part of that, but the biggest part of improving the record is *you*.

Check in before you give yourself a chance to check out.

On the cover: Bill Keyes' turbine-powered S-51, Lil Stinker.
(EAA photo by Jim Koepnick.)

EAA EXPERIMENTER

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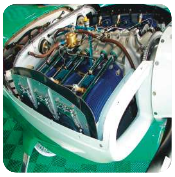

Readers React
To the "new" *Experimenter*!

The digital *Experimenter* provided a good read. Accessibility was good as well. While my specific interest areas are LSA, motorgliders, and ultralights in an E-AB context, the coverage of experimental subjects (e.g., the 1/3 B-17) helps in appreciating the work of other people.

Thanks for your efforts,

Harold Bickford
EAA 567796

I really like the digital *Experimenter*. Keep up the good work. I'm building a Pietenpol and love articles about homebuilding.

Arden Adamson
EAA 126141

Just finished the "new" *Experimenter* and must congratulate all associated with this enterprise…It is *great*! Will be looking forward to subsequent editions.

Doug Brownlee
EAA 28103

Pros
I like the format, the tool used to deliver, etc.
Article: Celebrating Older Homebuilts – Home run!
Article: Can't Keep a Good Plane Down – Good!
Hints for Homebuilders – Love these. And so few people know about them—why?
What Our Members Are Building.
Safety related articles—experimental—such as the article "Transitioning to Experimental or Unfamiliar Airplanes."
Flight Testing Techniques.
Lack of ads—good move!

Cons
Chapter News – Keep that in *Sport Aviation*.
Anything about certificated aircraft such as "Cessna to Change Skycatcher Certification"—what part of this is experimental?
Anything about Continental Motors' "diesel turbo" yada yada—what part of this is experimental?
News from HQ – Leave that for the EAA flagship publication. If HQ is building an E-AB, fine, otherwise I don't want to read about HQ.
Keep out articles about AirVenture—the most commercialized gathering of aviation. This is not grassroots E-AB stuff; better left to *Sport Aviation*.
The new *Experimenter* is a bit too much like *Sport Aviation*. Think about the *people* who build E-AB and stop writing about companies like Cessna and Continental. And I would like to see a heavy emphasis on safety of E-AB—how can the E-AB builder make a safer plane and improve E-AB safety overall.

Bob Dewenter
EAA 773828

Send your letters or comments to experimenter@eaa.org.

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EAA Member Donates Piper Cub Replica

The EAA AirVenture Museum received a tremendous gift this summer from longtime EAA member and AirVenture volunteer Marv Hoppenworth, EAA Lifetime 2519, of Cedar Rapids, Iowa, and EAA Chapter 33, who presented the museum with a homebuilt replica of a Piper Cub on the 75th anniversary of William Piper's masterpiece.

Marv spent countless hours building a full-size Piper Cub replica for donation and static display in the museum and worked tirelessly to get it completed in time for EAA AirVenture Oshkosh 2012. The replica contains parts from more than 20 different Piper Cubs and was built in the memory of Marv's very first airplane, a Piper Cub that he bought in 1948. "It was a Piper L4-H that I purchased from the pilot, Mr. Vernon Sandrock, who was flying it at the end of World War II," Marv said. "I have borrowed the registration number, NC9245H, from that Cub for this museum Cub."

The replica aircraft is now at Pioneer Airport waiting to be moved into the museum to truly honor Marv's achievement and generosity for years to come. Marv and his wife, Cathy, are longtime volunteers at AirVenture, helping to make EAA's international celebration possible. He has provided limitless entertainment for children with his famous pedal plane kits and plans. The pedal planes that are used at KidVenture to entertain our youngest visitors are of Marv's creation. To quote Marv, "There are two seasons in Iowa: before Oshkosh and after Oshkosh."

20 YOUNG EAGLES EAA ANNIVERSARY 1992 2012

Sporty's Enhances Flight Training Program

Sport pilot course among upgraded options now available to youth after first flight

EAA and Sporty's Pilot Shop's partnership has allowed more than 15,000 EAA Young Eagles to pursue aviation interests beyond their first flight through Sporty's Complete Flight Training Course, as part of EAA's Flight Plan program.

The EAA Flight Plan begins with an introductory Young Eagles airplane ride with a volunteer EAA pilot in a GA aircraft. From there, participants have access to a free EAA student membership, the Sporty's online course, a free first flight lesson at a local flight school of their choice, and numerous scholarships available to support continued flight training until a pilot's certificate is obtained.

Now Young Eagles will have upgraded options to further explore aviation as Sporty's Pilot Shop makes its Sporty's Learn to Fly Course available to all Young Eagles. The upgraded course is offered at no charge.

"Our recently introduced Learn to Fly Course gives tremendous flexibility to folks starting their flight training," said Sporty's President and Chief Executive Officer Michael Wolf. "The Learn to Fly Course is a modular program that gets everyone focused on the most important first step—solo. Then users are given their choice to pursue a sport, recreational, or private license."

Sporty's Learn to Fly Course is delivered in new HTML 5 format, making it usable not just on your desktop computer but also on iPads and other mobile devices.

» For more information about the YE program, visit www.YoungEagles.org.

Eagle Flights Taking Off

Pilot Tom Sampson (left) and Michael Martinez (right) after their Eagle Flight in Tom's RV-7A.

EAA's new Eagle Flights program introduced at AirVenture offers introductory airplane rides to adults who have always had a desire to fly, but for whatever reason have not yet pursued it.

Members of EAA Chapter 105 of Hillsboro, Oregon, wasted little time getting their efforts off the ground by hosting an Eagle Flights rally a week after the convention at Twin Oaks Airpark (7S3). Nineteen would-be pilots got introductory rides, and five of them gave their commitments to begin flight training and pursue a pilot certificate.

One of those future pilots, Michael Martinez, flew with EAA member/pilot Tom Sampson in his RV-7A. They did some routine pattern work, including several flying maneuvers. After landing, Martinez vowed to take advantage of what he experienced and pursue his pilot certificate.

Learn more about the program at www.EAA.org/EagleFlights, or call 800-557-2376.

EAA Urges Participation in Annual GA Survey

Every year the FAA surveys the GA community to obtain accurate information on aviation activity and safety. The 34th annual General Aviation and Part 135 Activity Survey (GA Survey) gets underway this month, seeking information on activity occurring last year.

The survey is the only source of comprehensive information on the activities of the GA fleet, including the number of hours flown and the purposes for which owners and operators use their aircraft. Survey results help determine funding for infrastructure and service needs, assess the impact of regulatory changes, and measure aviation safety. The GA survey is also used to prepare safety statistics and calculate the rate of accidents among GA aircraft.

A sample of pilots received a postcard invitation to participate in this survey in late August. Only members who receive a mailing are asked to complete the survey. Respondents may complete the survey online or by mail. The cutoff date for survey responses is November 30, 2012.

EAA supports the FAA in this GA activity fact-finding survey, and asks that members who receive the survey complete it as requested.

EAA Employees to Build a Zenith CH 750 E-LSA

EAA staff members have begun work on a Zenith STOL CH 750 kit, with EAA Communities Manager Chad Jensen leading the project. "This is a fantastic opportunity for EAA to show our love and appreciation for homebuilt airplanes," Jensen said. "The response I've received from interested staffers has been phenomenal!" Zenith President/CEO Sebastien Heintz has graciously offered EAA an airframe kit for the STOL CH 750 E-LSA.

"Support of the E-AB community is something I am committed to doing, and seeing an opportunity like this to work with EAA on a project that will not only provide an education to their employees, but also to see a group project come together and end up in the EAA Employee Flying Club is something I am very proud to be a part of," Heintz said.

Pilot's Bill of Rights Beginning to Pay Dividends

FAA has issued a notice implementing elements of the recently passed Pilot's Bill of Rights. Under the new law, which received the President's signature on August 3, pilots now have the right to obtain "air traffic data" relevant to an FAA enforcement action from government contractors. This includes information such as recordings of flight service briefings from contract facilities and communications with contract control towers. Previously, only services provided directly by the FAA and its employees had been subject to such requests.

The notice directs inquiring pilots to the new Pilot's Bill of Rights page on the FAA website, where a pilot who is the subject of an investigation may submit a request for air traffic data to a central point of contact within the agency. Requests made to this point of contact will promptly be passed on to the appropriate contractor.

The FAA cautions that air traffic data is commonly disposed of within as little as five days through the course of normal business. Therefore it is imperative that pilots ask to secure this data in a timely fashion and carefully describe the nature of the information sought, including time of day, altitude, and heading of the aircraft if possible.

The EAA sees this notice and the accompanying webpage as a very positive step toward the FAA's full implementation of the law. Doug Macnair, EAA vice president of government relations, was pleased with the announcement, saying, "This is the first tangible sign of benefit to airmen from our hard work on the Pilot's Bill of Rights as we seek to improve the level of fairness and accountability within the FAA enforcement process. We deeply appreciate the agency's responsiveness and support in bringing about the new procedures."

For additional information, EAA members may call Government Programs at 920-426-6522 or send an e-mail to govt@eaa.org.

FAA Issues Emergency AD for Some Rotax 912 Engines

The FAA issued an emergency airworthiness directive affecting certain Rotax 912 series engines. The AD requires that the pressure side fuel hose be replaced on fuel pumps with the following serial numbers:

11.3117 through 11.3325 inclusive
11.4036 through 11.4355 inclusive
11.4516 through 11.4595 inclusive
12.0251 through 12.0270 inclusive.

An AD from the European Aviation Safety Agency indicates that the pressure side fuel hose on these pumps may not be manufactured to full fuel-resistant standards, which could result in the degradation of the interior of the hose and result in debris fouling the fuel system.

The AD became effective on September 10. Affected owners have five flight hours from that date to make the prescribed repairs. EAA advises owners of Rotax 912-powered aircraft, both type certificated and non-type certificated, to check the AD to determine if their engine is among those affected. For more information, EAA members may call EAA Aviation Services at 920-426-5912.

PRA Joins FAA FAASTeam to Represent Light Rotorcraft and Experimental Aircraft

The FAA and the Popular Rotorcraft Association (PRA) signed a letter of understanding creating a high-level relationship between the two organizations. This agreement establishes official contacts between the FAA and PRA to share national media resources, develop safety training, and exchange safety materials between both organizations.

Established 50 years ago, the PRA is the only major U.S. organization representing personal rotorcraft such as light-sport experimental amateur-built, ultralight, and certificated rotorcraft.

The PRA has already created the first WINGS safety presentations to contain specific information about how GA aircraft can safely interact with light rotorcraft operations. Through the FAASTeam Industry membership, the PRA will be able to not only create more safety programs but also make these programs nationally available.
PRA Officers and Board of Directors strongly urge all personal rotorcraft owners, pilots, and student pilots to join the WINGS and FAASTeam programs (www.FAAsafety.gov).

Bearhawk Introduces LSA Model

Bearhawk designer Bob Barrows introduced his newest design, the Bearhawk LSA, at EAA AirVenture Oshkosh 2012.

While the Bearhawk LSA looks similar to the two-place Bearhawk Patrol, the LSA is really a clean-sheet design, with a new airfoil designed in part by Harry Riblett. The LSA's construction is similar to Barrows' previous projects, with the fuselage and tail surfaces using traditional 4130 chromoly tube and fabric design. The wings are all-aluminum, flush-riveted, with a single strut. Empty weight is 728 pounds, with an aluminum prop and no electrics.

Barrows reports an economy cruise speed of about 100 mph, sipping only 4 gph with the 65-hp Continental engine.

Currently, the Bearhawk LSA is only available as a plans-build project, but Bearhawk Aircraft is in the process of tooling up to manufacture quick-build kits. For plans, contact Bob Barrows, R & B Aircraft, at 540-473-3661. For kit information, contact Bearhawk A ircraft; call 877-528-4776 or e-mail info@bearhawkaircraft.com.

STOL CH 750 Now Available as Factory-Assembled LSA

Zenith Aircraft Company's popular light-sport utility design, the STOL CH 750, is now available as a factory-assembled LSA from Tennessee Aircraft Development LLC (Tenn-Air). The large-cabin aircraft, powered by a six-cylinder Jabiru 3300 engine, is being offered at the introductory price of $74,900.

According to Pete Krotje, head of Jabiru USA, Tenn-Air has licensed the design rights from Zenair Ltd. to produce the all-metal, high-wing CH 750 as a factory-assembled LSA. Tenn-Air will purchase STOL CH 750 kits from Zenith and assemble them to LSA standards at its factory in Shelbyville, Tennessee.

The STOL CH 750, often called a "Sky Jeep," is optimized for off-airport operations and short takeoffs and landings, using fixed-wing leading edge slats and other high-lift design features. The all-metal aircraft is configured with a standard steerable tricycle-gear configuration, with a large, high-visibility cabin. New features include available adjustable seats and a raised cabin for even more head room.

For more information, contact Pete Krotje at 931-680-2800, or visit the Tenn-Air and Zenith websites.

NTSB: Worn Parts Led to Fatal Crash at Reno 2011

Deteriorated locknut inserts that allowed trim tab attachment screws to become loose and induce aerodynamic flutter led to the deadly crash of Jimmy Leeward's *Galloping Ghost* race plane at the 2011 National Championship Air Races in Reno, Nevada, the National Transportation Safety Board (NTSB) reported. The flutter, caused by the reduced stiffness in the elevator trim system, broke the trim tab linkages, resulting in a loss of controllability and the eventual crash, the NTSB stated.

According to a news release from NTSB, the crash on September 16, 2011, occurred on the third lap of the six-lap race as Leeward's highly modified North American P-51D was traveling at race speed estimated at 445 knots (512 mph) and experienced a left-roll upset and high-*g* pitch -up peaking at 17.3*g* and causing incapacitation of the pilot. Seconds later, a section of the left elevator trim tab separated in flight. The airplane descended and impacted the ramp in the spectator box seating area, killing the pilot and 10 spectators and injuring more than 60 others.

The NTSB also concluded that "undocumented and untested major modifications" on the aircraft, as well as the pilot's operation of the airplane in the unique air racing environment without adequate flight testing, contributed to the accident.

Read a synopsis of the NTSB report, including the probable cause and a complete list of the safety recommendations.

Wicks Aircraft Supply Announces 4130 Shortage Is Over

4130 chromoly tubing, the traditional foundation of tube-and-fabric aircraft and a substantial component in landing gear, engine mounts, and roll structures, is available again in quantity from Wicks Aircraft Supply.

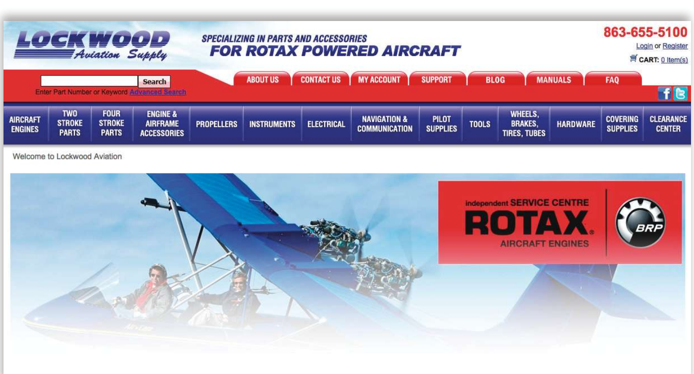
Wicks' 4130 chromoly tubing is seamless, rather than welded, and is sold by the foot or by full lengths (usually 18 to 24 feet, depending on diameter). Special-order lengths are also available.

Wicks has nearly 200 ways to supply 4130—e.g., sheets, bars, strap, rod; and round, square, rectangular, and streamline tubing. Wicks also carries 4130 TIG filler and other welding supplies to help with fabrication and finishing.

Wicks is currently offering a special price on one of the most popular sizes—1-5/8-inch OD, .083-inch wall tubing has been reduced from $3.79 per foot to $2.99 per foot (part number R1-5/8x083-41).

Visit www.WicksAircraft.com for more information.

Lockwood Aviation Launches New Website



A new Lockwood Aviation website uses a large number of innovations to make shopping for Rotax parts easier. "More than 3,500 of the parts and supplies that Lockwood carries are now online," said John Hurst, director of sales and technology. With more than 2,000 photos, including engine and airframe parts, tools, and supplies, customers can completely configure and purchase Rotax Aircraft engines online, including the new 912 iS." It also has real-time online inventory. For more information, visit www.Lockwood.aero.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Bill Keyes' **S-51T**

When 12 cylinders just aren't enough

By Budd Davisson

There is one image that, in one form or another, seems to stick in every pilot's mind: It's a clear summer day, and you are screaming across the landscape, guns armed, the Merlin in the nose singing its tight, raucous song, the enemy just out of sight…waiting…ready to pounce. But your Mustang and you are ready, too. You were born ready.

Everyone wants his own Mustang because everyone, it would seem, is in love with its looks and its place in history. But not everyone can afford one. In fact, very few people can, which is just as well because there are very few original Mustangs in existence. Still, the desire is there, making the P-51D Mustang probably the most modeled, most photographed, most chronicled fighter of World War II.

It is possibly the most revered airplane of all time. So, it would only make sense that scale modelers, who are continually increasing the size of their models, would eventually approach 1:1 (full size) scale. Is that what Jim Stewart did when he developed the Stewart S-51 in 1996? Did he design and build a man-carrying scale model of the Mustang that is approximately 70-percent scale in size but 100-percent scale in terms of excitement? Bill Keyes of Louisville, Kentucky, thinks that's exactly what Jim did.

Bill said, "If you have nothing around it to give scale to a Stewart Mustang, people sometimes have trouble telling it from the real thing. Especially those S-51s that aren't fully painted, so they show their aluminum structure and are using the Chevy V-8, as Jim originally intended. About 14 S-51s are currently flying with another 20 to 30 being built. Mine is the only one with the turbine engine."

"If you have nothing around it to give scale to a Stewart Mustang, people sometimes have trouble telling it from the real thing."

The Stewart S-51 is certainly one of the more ambitious homebuilt kits ever seen. For one thing, the Mustang is not a simple airplane to replicate because of its flowing lines, which required multiple stretch-formed skins. Also, when scaling an airplane down in size, there's not much you can do about scaling the pilot down. He is what he is, and the airplane has to be built around him. This design difficulty is compounded by the fact that a 70-percent wingspan actually means the cubic area available for the pilot is less than half that of the original. So a full-sized pilot has to go into half the space.

Bill said, "The only area that from a distance tells onlookers that this is a replica is the very slightly increased size of the canopy. Jim wanted this to be a two-place airplane, but with a perfectly scaled canopy, there wouldn't be enough room. As it is, it's really only a one-and-a-half place aircraft. My son would fit at 14 years old, but not now at 22. And, of course, the pilot

Bill Keyes

looks bigger than he should in comparison to the airplane. But that's it. You can look at it from any angle and it has 'that' look! It looks like a Mustang. The best part, however, is that from the pilot's point of view, it is indeed a Mustang."

As indicated by the sewer pipe-size exhaust stack on each side of the nose, Bill's Stewart Mustang isn't just any Stewart Mustang. Bill explained, "Jim Stewart originally designed the S-51 to be powered by a big-block Chevy, a 454 or larger, with a gearbox to reduce prop rpm. However, when Bob Wahl built this airplane back in 1999, he decided to go with a Czech-built Walter 601D turbine that puts out 724 hp. He sold it to a friend of mine, and in 2004 I bought it. I'd always wanted a Mustang and now I had one! Sort of, anyway."

An obvious question is "How does one learn to fly a 724-horse, single-place taildragger?"

"I had about 150 hours of taildragger time," Bill said, "most of that in Cubs and Huskys. I had bought a Super Cub, then a Husky, to use in teaching my son how to fly. So, I didn't have a lot of tailwheel time. Plus, even though I'd flown RF-4s in the USAF, I'd never flown a civilian airplane with that much power. My checkout consisted of Brad Hood kneeling on the left wing while I sat in the cockpit. He said something to the effect of '…and then you flip this switch, turn this lever, and…' I was really keyed up, so you can imagine how I felt when I taxied out to the end of the runway and couldn't get the canopy cranked all the way shut. I had just gotten my nerves under control, then had to taxi back, spend three hours fixing the canopy, then had to go out and do it again. It was double jeopardy! I was nervous, but the first part of the flight went without a hitch.

Power for Bill's aircraft is a Walter 601D turbine engine.

"I had flown about an hour and done five or six landings, then was taking it back to my home field when things went wrong. I had touched down, and the airplane wanted to start a very slow turn. I put the engine in beta with the tail off the ground, but I couldn't keep it straight. Then I noticed a wingtip going down and I knew a gear leg was folding. This was all happening in slow motion, and I had no problem keeping the wing up as long as possible. Then I gently let it down and watched as each prop blade hit the ground, each one making a very distinctive, unpleasant noise. Then I ground to a halt only about four feet left of the edge of the runway."

An autopsy of the folded gear showed that two problems had worked together to bend Bill's airplane: a design change that upgraded the main gear trunnion axles from 1015 mild steel shafts to 4130 chromoly hadn't been communicated to the original builder. Plus, too many holes had been drilled through the trunnion axle for the down-lock collar. The result was a break through the bolt holes, which allowed the gear to collapse.

Bill said, "The wing hit hard enough that there was a three-inch crack

in the main spar with a shorter one in the rear spar. Both were just outboard of the gear mount. The flap was kinked in the middle, and the prop was trashed. The internal condition of the engine was a big question, so it went out to Diemech Turbines in DeLand, Florida, the Walter engine experts, where it was torn down and rebuilt. Fortunately, since it wasn't a sudden stop, the internal condition was surprisingly good. In the meantime, I started taking things apart. Very shortly I decided that if you're going to get this far into an airplane, you might as well do everything you've wanted to do, and that's

Bill's S-51 parked in the Replica Fighters area at AirVenture 2011. If you're a fan of replica aircraft, you can learn more about the Replica Fighter's Association at www.ReplicaFighters.net.

exactly what I did. Essentially, with the help of Jerry Zollman, I rebuilt most of the airplane.

"I had to de-skin the entire left wing panel to repair the spars, and to do that right, I took the fuselage off the wing and split the wing into its component parts for compete access. Since the turbine burns more fuel than a Chevy, the plan was to add extended aux and main tanks. The wings are wet, which required a lot of sealing and testing, then resealing and more testing. The first time around I had lots of leaks. It was a very tedious process, but it gave me a total of 140 gallons, which is really nice. I burn about 40 gallons an hour in cruise, so this gives me a decent range with a good reserve.

"The doghouse that normally covers the radiator on the bottom of the fuselage had kissed the ground, but just barely. I was lucky there because it just took some judicious sanding and buffing to get rid of all the scratches. That was fortunate because those are all compound curved skins and not easy to replace.

"When we rebuilt the gear, I had new trunnions machined out of 4130 chromoly, but rather than through-bolting it, I used cylindrical locking nuts that required no through bolts. I'll never see them crack again.

"As long as I was working on the gear, I had never liked the single-fork tail wheel, so I modified it. I made up a new dual-fork tail wheel with a larger shock spring. The tail wheel lock now works on the stick, just like a real Mustang. With the stick anywhere but forward, the tail wheel steers six degrees either direction. But, when you want to turn sharp, you push the stick forward, and the tail wheel unlocks and full swivels, allowing tight turns. Many of the improvements are the result of the work done by the builders' group."

Once you get an airplane apart, you quickly run out of excuses not to do things, and a simple repair turns into a complete rehab where the owner puts some of his own DNA in the airplane through sweat and busted knuckles.

"I figured, what the heck, I'm only going to do this once," Bill said, "so I completely gutted the interior and tore the entire instrument panel out. All of it. Then I made up a new instrument panel. Well, actually, I made six of them because I either had problems in making them or found I didn't like some of the arrangement. As it turns out, the first arrangement was the one I came back to in the end. Isn't that always the way?"

Bill obviously got his S-51T back in the air, and in the end, knew much more about the airplane than when he bought it.

He said, "When you go completely through an airplane the way I did, cleaning up and changing everything to both fit your mission and work better, it does a lot for your confidence in it. So, I fly the airplane more comfortably now than I think I did at the beginning.

"As for how it flies, it's pretty much everything you'd want in an airplane. A real fighter. On takeoff, as long as you remember to preset right rudder trim, it's pretty easy to keep straight, and with 724 horses dragging you down the runway, takeoff doesn't take very long. As soon as you're off the ground, the throttle comes back to 657 horses, and at cruise you're right at 380 hp, which gives 250 mph at about 40 gallons per hour. That's a pretty conservative setting. It'll go a lot faster, but at that setting I have a solid two-and-a-half hours with one hour reserve.

The residual power at idle always gives a pretty good float, and ground effect keeps it up, but at 70 mph it's on the ground.

"On approach, I get the first notch of flaps at 140, which helps slow it down; the gear is down at 125 and I'm flying downwind at 100 mph. I try to have 80 to 90 over the fence and it stalls at 72. The residual power at idle always gives a pretty good float, and ground effect keeps it up, but at 70 mph it's on the ground. Once on the ground it's a no-sweat operation. However, when taxiing it, if you stick your head around the windshield while S-turning, it's like sticking your head out into a hair dryer, and it'll blow your glasses and hat off."

The allure of the Mustang is universal, something that Bill enjoys.

"I'm never alone at the gas pump," he said. "It gathers a crowd because everyone on the planet seems to recognize and like Mustangs. So it's really fun to take it places. The only thing missing is the magic sound of a Merlin."

Hmmm…with all of the creativity EAA homebuilders seem to have, we're wondering how long it'll be before Bill designs an audio system that produces that distinctive 12-cylinder bark. As he has said, projects like his Mustang are never truly finished. EAA

Budd Davisson is an aeronautical engineer, has flown more than 300 different aircraft types, and published four books and more than 4,000 articles. He is editor-in-chief of Flight Journal magazine and a flight instructor primarily in Pitts/tailwheel aircraft. Visit him at www.Airbum.com.

Photography by Tyson Rininger

Aerochia's First: The LT-1

The plans-built grand champion at AirVenture Oshkosh 2012

By Tim Kern

It's not often that a new airplane builder has a test pilot volunteer to do first flight and development flying. But Andy Chiavetta, former nationally ranked (number five) skimboarder-turned-raceplane builder, had the respect, advice, and curiosity of not only race partner Darryl Greenamyer (four-time Sport Class and seven-time Reno Unlimited champion) but also top test pilot Len Fox, as Andy brought his dream to the air this spring, and then to EAA AirVenture Oshkosh.

Len explained the plane's flight characteristics, after some 20 test flights (including the plane's first). His insights are telling, both for Aerochia (Andy's company) and for any would-be designer or builder.

"I first saw this airplane as a drawing on [aerodynamicist] Greg Cole's office wall in Bend, Oregon," said Len. "When the time finally came for the first flight, Andy's friend Darryl Greenamyer wasn't available, so I was happy to oblige.

"As a test pilot, you look at a new plane with an eye for what may present a problem. With this airplane, all the things I thought might be problems weren't. There was plenty of rudder, plenty of aileron, plenty of elevator, and there wasn't any blanking or slop in the controls."

So, Len felt confident before he left the ground.

"When you're flying, it does just what you want it to do: Center the stick…boom!…the plane stops rolling. Good ailerons make for smiling pilots. This one makes me smile."

Performance, as Measured So Far

Len continued, "After we calibrated the airspeed indicator, we found that the stall came at 47 knots. When we called Greg Cole and asked him what he had predicted the stall speed to be, he said 47 knots. "With the stall strips, the airplane stalls straight ahead. The roll rate is about 120 degrees per second: crisp, but not twitchy."

One of the modifications to the HKS engine that powers the LT-1 was to replace its twin carburetor setup with a single carb. Len thinks this interim modification is responsible for a reduction in horsepower from the rated 60 hp. (Andy Chiavetta admits to a very quickly made air filter arrangement that he can't wait to improve.)

Additionally, the airplane has not yet flown with its wheelpants. "Gear on this airplane is a huge portion of the drag." Still, Len said, "With the cruise prop, and no wheelpants, and probably down on power, it goes 129 knots." That's 148 mph. Oh, and the flight tests are being conducted in Thermal, California, in the summertime. Andy's design top speed of 150 mph seems pretty reasonable.

Approach can be made as slow as 65 knots. Takeoff in this light airplane is very quick, considering its small wing (60 square feet), lack of flaps, and modest power. Len said, "On the worst day, with the prop at steepest pitch, we use maybe 1,000 feet of runway."

Flight Report

Len noted that he felt "no strange vibrations. The throttle is smooth; it's easy to take off, easy to fly; smooth and responsive."

So far, test flights have mapped the heart of the CG envelope.

"One way to check when you're approaching the aft limit of stability," Len explained, "is when you do a standard turn, and then tighten it up, adding *g*'s. You should always have positive stick forces. If the stick falls into your lap, you don't have enough horizontal tail. At the design aft CG, this airplane has enough."

"When you're flying, it does just what you want it to do: Center the stick…boom!…the plane stops rolling."

He liked the approach and touchdown, too. "The gear is in the right place. You can flare, touch down on the mains, and gently let the nose down. It tracks straight on the ground."

Partially this comes as a result of just 60 nominal horses and a well-sized rudder. "There is very little P-factor. With the controls, you feel connected to the airplane. Ailerons and elevator have little or no free play, and there are no aerodynamic dead zones; when the control surface moves, the plane moves. There's a direct connection between the pilot's brain and the control surfaces. Controls are light but not twitchy; they have a good centering feel. The LT-1 has the immediate reaction of a high-performance aerobatic machine, but the pitch and roll rates induced per inch of stick movement are less. With a flick of the wrist, aileron response is immediate, but you get 5 degrees angle of bank instead of 50."

Len also said it's no effort to fly, including pulling it into and out of the hangar. "A test pilot likes a

At 5 feet, 8 inches tall, author Tim Kern had plenty of headroom in the LT-1. But even a 6-foot, 5-inch tall pilot had plenty of clearance for a headset. Cockpit width is 27 inches.

plane that is built right, flies right, and is fun to fly. This plane makes me smile."

How big is that smile? "From seeing the line drawing in Greg Cole's shop to doing the first flight to test-flying it, well, I've put a deposit on one." Len Fox, professional test pilot, will be the owner of LT-1 serial number three.

Darryl Greenamyer Weighs In

Eleven-time Reno champion Darryl Greenamyer had a complaint: "I wish it went a thousand miles an hour faster." He laughed and said, "I'm just used to faster machines, but this airplane flies well and is easy to control." Darryl acknowledged that "He [Andy] has had some engine problems, but he's got them worked out. That's the only criticism I've had, and he's worked them out. He's still experimenting, though, making the engine better, and I think he has another idea, too," possibly referring to the turbocharged version of the HKS.

He continued, "The LT-1 flies well; it's easy to control. It handles well, feels good, *is* good. The airplane flies fine, works fine, has good speed for its power." Darryl, who is responsible for the name "LT-1" (the meaning of which is a secret, perhaps like the British "Lola" race car name), added that it "flies the pattern well; it has good low-speed handling. Some may want flaps, but I don't see the need." He summed up: "I like it."

Specifications and Performance

The single-seat plane is little, with 60 square feet of wing like a Formula 1 racer, but it's not a racing wing. The wingspan is 20.8 feet, and there are no flaps. It's simpler that way, and it doesn't need them. Overall length is just 15 feet. The world's tiniest trim tab, half the size of a stick of chewing gum, is on one elevator. Tiny stall dams on the leading edges aren't any longer than a cell phone.

With 18 gallons of gas in the two-wing tanks, minimum endurance should be well more than four hours, plus reserves.

Still, the LT-1 is comfortable and capable. With a useful load of 293

Photography courtesy Andy Chiavetta

pounds, it will haul a standard pilot, 15 pounds of luggage, and full tanks off a short runway. The cabin is 27-½-inches wide. That doesn't sound like a lot, but think about how wide a two-place, 55-inch cabin would feel! (For reference, a Cessna 172 is 39-½-inches wide, seated two across.)

Tall pilots will fit, as well. At AirVenture, one 6-foot, 5-inch volunteer hopped in, and he fit, with headset clearance on top and "didn't have to move the rudder pedals" legroom. When I put my 5-foot, 8-inch frame in the cockpit, there was a mile of space above me, and I could barely reach the pedals. (I wasn't wearing a parachute, but I was sitting on the foam pad.)

Visibility was astounding. Looking ahead, even from my artificially low position, was plenty adequate; I could just see the wings in my peripheral vision. Even with the round fuselage dominating your sight picture, keeping the wings level without relying on instruments should be a breeze.

Yes, more compact pilots will be able to fly the plane. Darryl, while a giant in the record books, is smaller than I am, and he's flown the LT-1 many times.

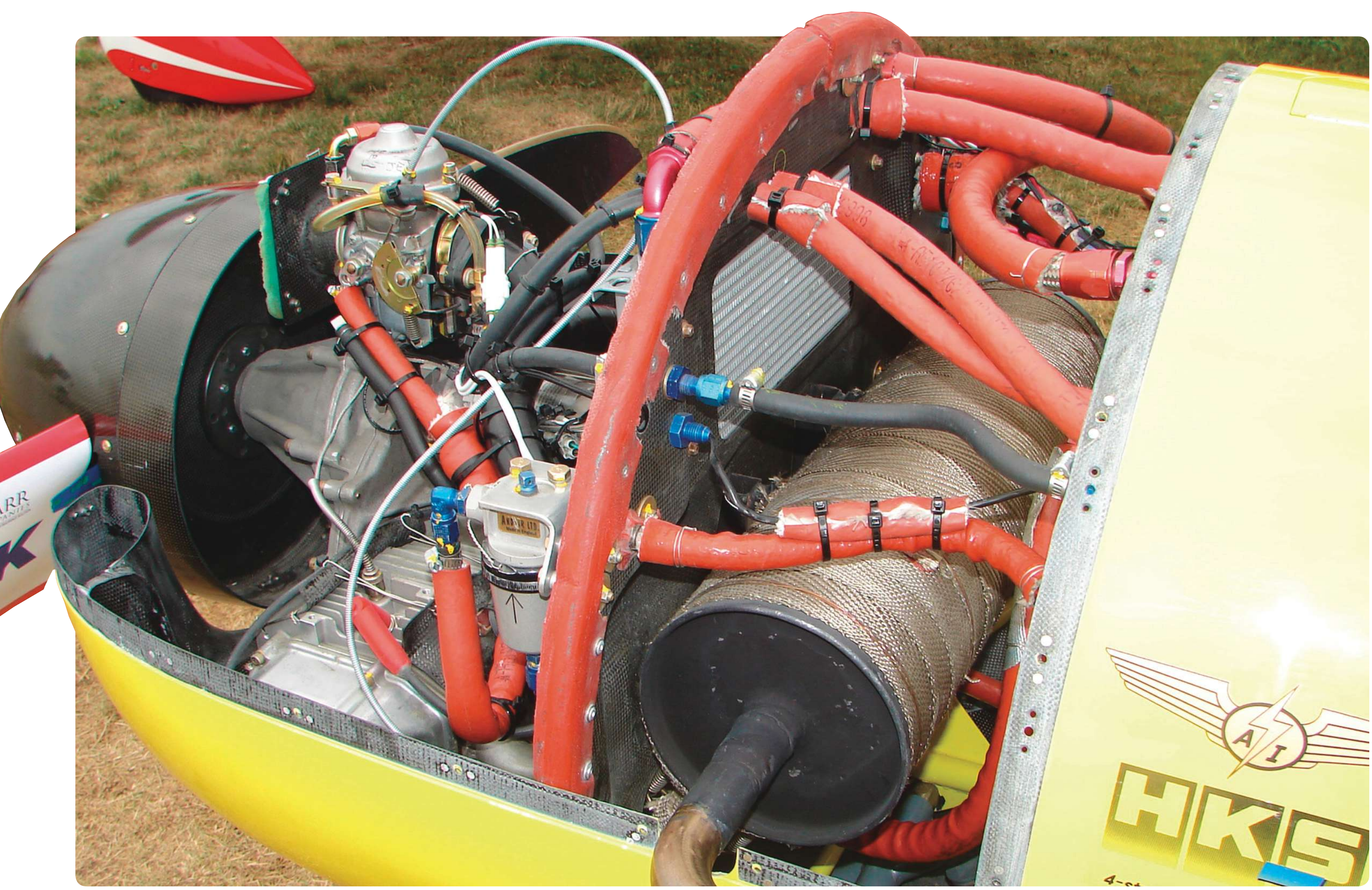
The LT-1 is aerobatic at +6/-4*g*, but it does not have inverted fuel and oil systems. Simple, remember?

At minimum weight and with a better airbox/filter arrangement, the LT-1 should easily make its claim of 1,000 fpm climb; the 650 fpm figure for MTOW climb also looks realistic.

Official, pilot's operating handbook–style V-speeds have not been determined, but design speeds of 120 knots at 60 percent and full speed at 140 knots are still listed on the website. But only 129 knots have been achieved so far. Remember, though, there are no wheelpants on this little machine, and they'll make a huge improvement. V_{NE} is listed as 180 knots.

The Plane's Boss

Andy likes to make things out of composite materials, and since his days as a hardcore skimboarder, his craftsmanship has been an



The LT-1 is powered by the 60-hp HKS 700-E engine. The turbine HKS engine could also be an option.

important contributor to his results. For a decade now, he has been building composite go-fast parts for Lancairs and other "glass" birds; his modifications and parts are found on virtually every Lancair at Reno, including that of Darryl Greenamyer, for whom Andy also served as crew chief.

Andy wanted to build his own airplane, and Darryl, who knows everybody and has flown pretty much everything with wings, was a great mentor, from the early stages right through the current test regime. Darryl's influence is there, but the design is all Andy's. "And the wing is Greg Cole's," Andy reminded me.

The design was to have been simple and inexpensive to manufacture, to build, and to fly. "Keep it light. Keep it simple. Keep it inexpensive," Andy said, "and it will be easy to build." As many of Andy's crew have noticed, keeping it light (about 500 pounds) makes it easy to maneuver on the ground and in the hangar. "One hand is all it takes to bring it out of the hangar," he noted.

Andy spends a lot of time in the shop, so he knows what takes the builder's time, and he engineered the LT-1 kit to have a minimum of shop time while still complying with the 51 percent rule. "The molding is mostly done," he said. "The builder needs to do just a few small layups." These small parts are easy to handle and provide skill in composite work, which will be useful down the road when the builder is repairing or modifying his machine.

"Look at the website; you can see the wing, the spars, fore and aft," Andy said. "They're in the wing when you get the kit. The builder can literally start installing hardware."

The fuselage is split horizontally, the easier to install the controls. "It's easy to work on at waist level [the shipping fixture is great for this], before bonding the top half on," he added.

Fuselage assembly itself is simple. Andy said, "You use structural adhesive, clecos to hold it until it sets. Then you pull the clecos, patch the holes, and it's done."

Andy likes to make things out of composite materials, and since his days as a hardcore skimboarder, his craftsmanship has been an important contributor to his results.

The firewall-forward setup is easy. HKS supplies a very effective (and *big*) muffler; Andy's single-carb intake may remain and become refined, or he may opt to have the builder tune the stock two-carburetor setup. The noticeable black bumps on each side, near the rear and under the cowl, are cooling air exits. "I'm still optimizing the shape," Andy said.. "Right now, we have at least all the cooling we need—and our tests are being flown at Thermal, California!" For now, they just screw on, as Andy tests various configurations.

Sure, there's work. Andy said, "As a manufacturer, we can't close out everything; we have to comply with the 51 percent rule. Still, this is a kit plane, not a scratchbuilt. Don't get me wrong; there's still work to do, once you get the kit."

Andy figures that a highly experienced builder who had never built an airplane—but who has a dedicated garage or hangar and the ability to concentrate on building—could build an LT-1 in three months. For others, he thinks "up to a year for an enthusiastic amateur."

The design is simple and inexpensive. There are no machined hinges, for instance; everything's hinged with piano hinges. Another simple, cheap, light trick: The tubular gear legs are housed in simple carbon-fiber sheaths.

Pricing

Andy is planning to complete the airframe kit for around $30,000, with deliveries to regular customers (he's already building No. 2 and No. 3) starting around Oshkosh time in 2013. Although the spinner and plate are included, the kit does not include the HKS engine, prop, paint, and instruments. Yes, the 60-hp HKS gives plenty of performance, but there is room for the turbocharged version. Other engines will likely find their way into the spacious, round cowl.

Summing up, Andy told me, "My philosophy was to make an easy airplane to build and to fly; safe, affordable, and comfortable." It looks like he did it. EAA

» For more information, visit www.Aerochia-LT1.com.

Tim Kern is a private pilot who lives near Indianapolis, Indiana. He has written for more than 40 different aviation magazines and also provides writing and marketing services to the aviation industry. He was key builder on two aircraft and has earned the title of Certified Aviation Manager from the NBAA.

While still in the construction stage, it's easy to see this will be a sporty airplane to fly.

Panther Sport Plane

By Patrick Panzera, EAA 555743
Photos by Pat Panzera

My guess would be that the average homebuilder attending EAA AirVenture Oshkosh is probably most interested in seeing what's new and different. Sometimes that takes the form of progress by an emerging design. In 2010 we were introduced to David Algie's fire-breathing LP1 (an all-composite, Corvette engine-powered speed demon) that was shown at AirVenture; in 2011 we were privileged to see its progress. Although David is close to getting signed off by his DAR, he wasn't able to make it to AirVenture 2012. Hopefully we'll see his finished project at AirVenture 2013.

But this year we were introduced to something on the other end of the spectrum. Although it's also powered by a Chevrolet automobile engine (the air-cooled, six-cylinder Corvair), Sport Performance Aviation's Panther – brainchild of the company's president, Dan Weseman – is a single-seat aerobatic aircraft with ample room for even the most robust pilot. While it's primarily aimed at the light-sport market and has folding wings that take two minutes to rig, the Panther also can be built to exceed the light-sport aircraft (LSA) performance limits for pilots who want to have a little more fun. And although the cockpit is roomy, the seat and rudder pedals are fully adjustable so nearly anyone can fit without compromise, with or without a parachute.

Construction

The Panther's wings, tail cone, and empennage are constructed from 6061 aluminum using flush, blind rivets. The prewelded fuselage is built from a carefully selected mix of square and round 4130 steel tubing, from seat back to firewall, which is skinned with sheet aluminum. All critical attach points, such as the those for the solid aluminum (spring) landing gear legs, wing pin, engine mount, five-point harness, ballistic chute, rollover bar, control hard points, etc., are all welded in the jig. This allows for quick and accurate construction of all critical points, and the steel cage, with its integral rollover bar, offers added pilot safety in the event of an accident.

Because the folding wings lie flat against the side of the fuselage while trailing aft, hauling the Panther on an open, flat-bed trailer, such as a customized, recycled boat trailer, is an option that's hard to beat by those of us on a tight budget. The overall size of the folded aircraft is compact enough to be easily rolled into the rear of a 7-foot by 7-foot by 18-foot-long enclosed trailer and kept there until the next flight – no need for a hangar or extra space in the garage.

The Engine

Powering the Panther prototype is the aforementioned Corvair automotive conversion reported to make 120 hp from 3000-cc displacement and with a yet unproven fuel injection system. Stock Corvair engines are 2700 cc (164 cubic inches). But Dan is no stranger to the Corvair, having successfully installed one in a Sonex that he built and (out of respect for the designer's wishes) renamed *Cleanex*, as it was a *clean*-slate installation. The use of the Corvair in the Sonex, while generally frowned upon by the factory, is a good fit for the airframe, and Dan supports this option with a full line of the required accessories that make for a clean installation for those who want extra power for the Sonex at an affordable price.

While nearly every flying Corvair uses a carburetor, Panther creator Dan Weseman is planning to use mechanical fuel injection.

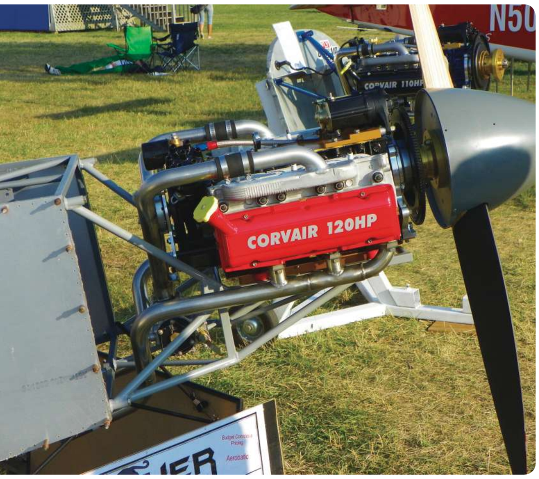
The integrated use of both square and round tubing, along with the simple and robust rudder pedal adjustment, show the forethought that has gone into the design of the Panther.

Panther LSA Specifications

Seats	1
Wingspan	23.5 feet
Wing area	93 square feet
Empty weight	650 pounds
Gross weight	1,020 pounds
Fuel capacity	20 gallons (in wings)
Engine	110-hp Corvair (or 80-120 hp)
Top speed	138-180 mph*
V_{NE}	200 mph
Aerobatic capacity	+6/-4.4*g*

** Maximum speed in level flight with maximum continuous power (V_H): 138 mph*

Dan has also developed and is marketing a "fifth bearing" adapter plate for the aero-converted, direct-drive Corvair engine that's designed to reduce some of the troublesome propeller loads from the prop end of the stock Corvair crankshaft. Although the stock General Motors crankshaft is forged and in some cases even nitrided, it was never designed to handle the gyroscopic loads imposed by the prop, so it only makes sense to increase the length of the front bearing to be more in tune with what we find in certified aircraft engines, and that's what Dan accomplished with his simple design.



The 3,100-cc Corvair engine is the staple for this design, although the airplane is tolerant of higher power, heavier powerplants; smaller, low-power engines can be used by those with a budget in mind.

And Dan has recently taken the Corvair conversion to the next level by creating (and marketing) a new billet crankshaft for aviation and automobile use.

And Dan has recently taken the Corvair conversion to the next level by creating (and marketing) a new billet crankshaft for aviation and automobile use. He's even gone as far as to offer the option to add stroke length, further increasing the displacement (and power) of the little horizontally opposed six-cylinder to a full 3400 cc (207.5 cubic inches), making approximately 134 hp at 3400 rpm, the normal speed for the direct-drive Corvair engine. But Dan's aim for this displacement increase is to provide the typical 120 hp at a reduced rpm, potentially upping the time between overhaul. This will work well in all LSA airplanes, especially high-drag aircraft like the Zenith 750.

Three Different Panthers

There are three different models in the making. The Panther LSA version has a wingspan of 23.5 feet, can use engines ranging from 80 to 120 hp, and will be offered with conventional gear or with a nose wheel. This will be the first of the three offerings to fly.

The Panther Long LSA is the same as the LSA version but with extended wings and horizontal stabilizer, each with tapered tips. It's designed to use smaller engines, including electric motors, for the most efficient flight. These will be tested on the prototype LSA airframe in the future, based on customer interest.

The Panther Sport version will have a wingspan of 21.5 feet but won't fit in the LSA category. It can handle anything from a stock 2700-cc Corvair to the 160-hp Lycoming O-320, and it will only be available with conventional landing gear.

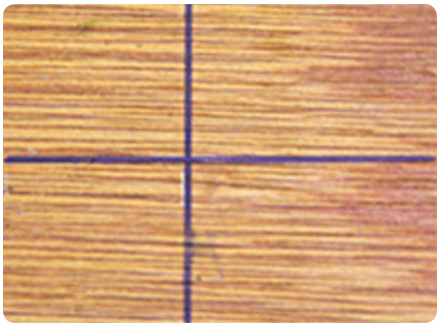
» For more information, visit www.SportPerformanceAviation.com/panther.html.

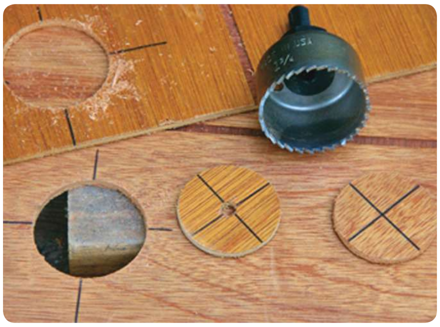
Video of the Month

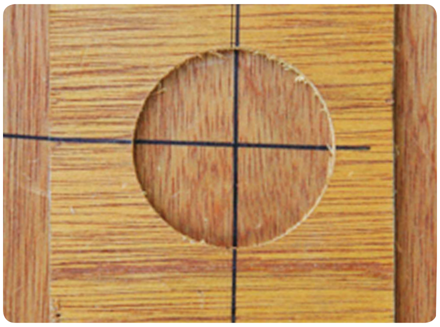
George Richards of New Zealand recalls his adventures building and flying his all-wood Falco homebuilt. George shipped his aircraft from New Zealand to California and then flew it to EAA AirVenture Oshkosh 2012. That's quite a story, too!

A "Holey" Tip
Cutting holes accurately

By Cy Galley







Hole saws are great; they don't kick back and can be used in a handheld drill. But wouldn't it be nice to use the cut-out disk without the ugly center pilot hole? We could cut a disk for a disk brake pad. Use the saw to cut inspection holes without worrying that the pilot drill will damage something behind the surface we're cutting, like a gas tank, fuel lines, or control cables. Other uses would be to cut gussets for wing ribs and inspection covers.

However, you cannot just remove the center pilot drill, as it locates and stabilizes the saw. We need something to hold the saw from "walking" and wandering; something to locate the hole.

The solution is to drill a hole through a piece of thin plywood, such as a scrap of paneling, with the pilot drill in place. Then use the hole in the plywood as a guide by clamping or taping the plywood where you want the hole. Use the lines to center the guide. Then use the hole saw without the centering drill. Some hole saws use the drill as a drive shaft; if so, you'll have to use a shortened drill.

The previously drilled hole in the plywood will provide all the positioning necessary to drill your new hole or create a disk without a hole in the center. Because you are using an outside guide, you even can saw less than a semi-circle.

If you are making several disks and have a quality hole saw, make the guide from 1/8-inch aluminum. However, if you are just making disks, stack enough layers and each layer will guide the next. Use a slower speed when cutting larger disks. A metal-cutting hole saw would make the job easier on aluminum. EAA

Hints for Homebuilders Videos

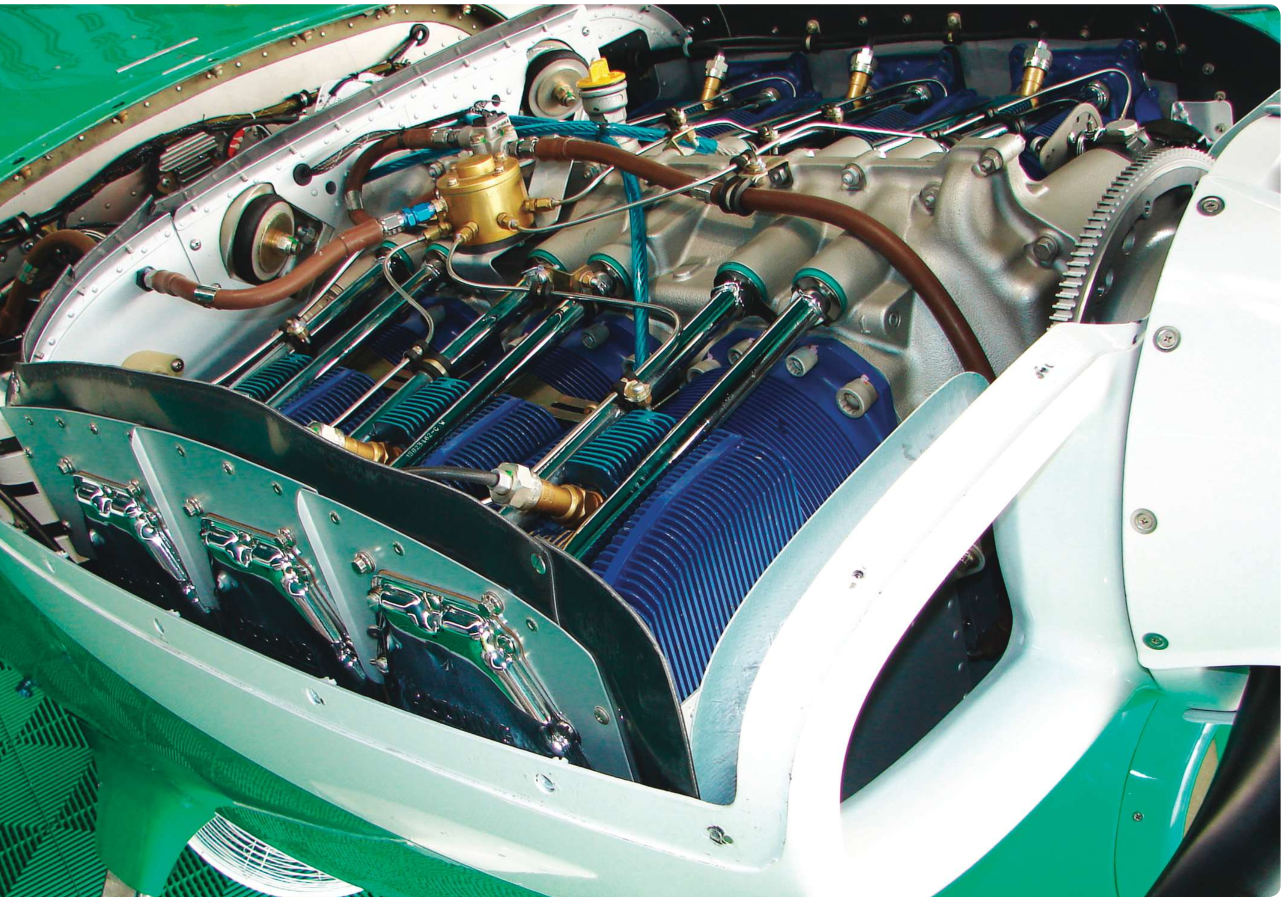
EAA has produced hundreds of hints for homebuilders videos. You can view them all here, www.eaavideo.org/channel.aspx?ch=ch_hints. Here's a sampling of the videos that are available.

Cotter Key Installation-Standard Method

Brian Carpenter, of Rainbow Aviation in Corning, California, demonstrates the standard method for installing a cotter key on a castle nut. Here's the video.

Cotter Key Installation-Alternate Method

Brian next demonstrates the alternate method for installing a cotter key on a castle nut. Here's the video.



Michael Goulian's 580-hp Lycoming-powered Red Bull racer does not let any air go wasted.

Baffling…
It needn't be

By Tim Kern

Aircraft engines, whether air cooled, air/oil cooled, or liquid cooled, are all ultimately cooled by transferring their heat to the air. This transfer is so important that we tolerate cooling being responsible for up to 20 percent of an airplane's total drag.

Understanding the basics of cooling helps us to understand how much cooling we need and how best to achieve it. The principles are simple; execution is not easy. (Mozart, it is often said, wrote simple music. *You* try it.)

The Basic Rule

We're not cooling engine size, compression ratio, or numbers of cylinders. We're cooling horsepower. A tiny 600-cc (37-cubic-inch) motorcycle engine making 100 hp needs the same amount of cooling as a 200-inch Continental O-200 that's making 100 hp. A TSIO 540 throttled back to 100 hp needs that same cooling, as does a Rotax 912S at full tilt, or a 427-inch Corvette that's loafing along, cruising at 120 mph and using 100 hp to do it. Vastly different packaging and purpose make the cooling systems look different, but the amount of cooling needed at any given output is virtually identical.

Two Important Generalities

Although the air gets colder as we gain altitude, it also loses density. Less dense air carries off less heat. Less dense air also reduces the power potential for normally aspirated engines. Adding a turbocharger to an existing design, even when that turbo does not raise top output but only allows maintenance of sea-level power to some altitude, raises engine output at any given altitude, and thus raises cooling requirements.

Drag increases faster than the square of the speed (many claim the cube; some, more than that—it depends somewhat on the speed range one is discussing), but the amount of heat the air carries away increases only linearly with speed. For example, doubling the speed increases drag by at least four times, but the amount of air going past the fins merely doubles.

So, the faster we fly, the higher we fly, the more critical becomes the cooling design.

Some Important Considerations

Air separates from the surfaces it covers when the angle increases beyond a certain point. In general terms, that's about 15 degrees; in a tube, the walls should converge or diverge no faster than about 7 degrees each. We know that when a wing's angle of attack exceeds about 15 degrees, we quickly trade lift for turbulence; the same thing happens to any air interface. So, when we're ducting air in our cowlings, gentle "ramps" are required. However, once we know we need to break that flow (22 degrees, say, is as bad as 90), we can then abandon the pretense of keeping airflow attached, and just deal with the drag and build the "easiest" solution.

Air cools as it expands and heats up as it is compressed. An extreme example is a diesel, i.e., compression engine, where combustible gases are compressed in the cylinders until they ignite simply from the heat generated by compression; no spark plug required!

Turbulence can be used to our advantage, if we are aware of it and exploit it.

Pressure, both high and low, can and should be exploited in the cooling design.

With propeller planes, the amount of air the blades move is asymmetrical in climb. We all recognize P-factor when climbing; the same phenomenon is in play when we consider how much cooling air the prop is forcing into the cowl. (Did you ever notice the little blanking plate in front of the "down blade" cylinder on many certificated airplanes? That's why it's there.)

Your cooling requirements extend to more than just your cylinders. Consider cooling your alternators, magnetos, batteries, etc., and don't forget the oil cooler!

Although crude "eyebrows" work on many slow airplanes, an integrated enclosed cowl/internal baffling system is more elegant and ever more efficient as aircraft speeds rise. Keeping the cooling air focused on its job is the duty of the inner cowl design, specifically the baffling.

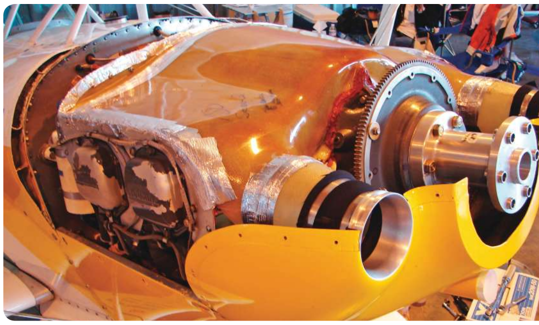
In "flat" (opposed cylinder) engine airplanes, the simplest enclosed designs consist of an opening in the front of the cowl for inlet air, a horizontal "tray" separating the top and bottom of the cowl, and an opening in the bottom of the cowl, to let the air out. The purpose of the tray is to direct the flow of cool inlet air through the engine's fins, rather than allowing it to find the easiest way out, bypassing the engine.

The next step is to build a vertical wall atop the tray, behind the cylinders, to concentrate the airflow. The gap between the cowl and the top of the metal "box" and the sides of the tray is typically closed with a sheet of flexible reddish silicone cloth. For slow airplanes, this can be sufficient; but it's inefficient.

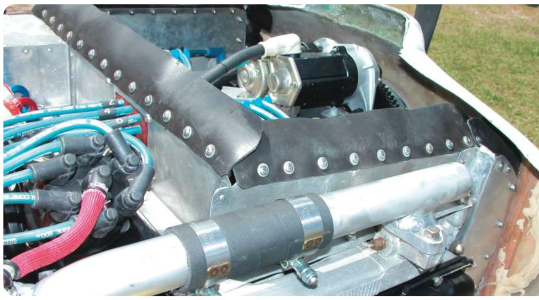
Other approaches are to attach the baffling directly to each cylinder bank. Jabiru, for instance, furnishes formed boxes that can be ducted forward to the cowl inlets, which fit well to the cylinders and heads. Put cold air in the front, and the factory-supplied ductwork carries it right to the hot spots.

It's important to put the cool air where it does the most good, and

Jeff LaVelle's Glasair topped 400 mph at Reno, partly due to efficient use of cooling air in a proper plenum.



Tony Higa's Pitts, set up for Reno racing, features an internal pressure plenum inside the original cowl.



W.G. Coppen's Corvair-powered SA-7 gathers all its air in the cowl and forces it through the six cylinders' fins.

that's usually the cylinder heads. Continental, in fact, showed some experimental O-200 cylinders a few years ago that had no fins at all. They run cool enough, but it turns out that the fins also serve as mechanical reinforcement to keep the cylinders round. (The newest O-200-D cylinders have much smaller fins that taper ever smaller toward the case, saving about a pound per cylinder.)

Better yet is to have equal pressure to all the cylinders, and one excellent solution is to build a single box that attaches to the top of the engine and encloses all the heads, supplying air more or less equally to all areas. This "plenum" design can get scientific, but some general principles always apply:

1. The plenum should not leak. Lost air is wasted drag.
2. The plenum should not chafe against the cowl or any other part of the airframe.
3. Baffling inside the plenum, if used, should concentrate airflow to the heads.
4. The plenum should not enclose exhaust components. Hot air won't cool your engine!
5. The plenum should have as much volume as is practically possible to allow uniform pressure inside the cowl and to allow maximum expansion of the outside air.
6. Inlets to the plenum should be as long as possible (it sometimes helps to use a prop shaft extension), and the inlets should expand as they approach the plenum, at no more than a 15-degree included angle. Inlets need to be smooth on the inside as well as outside!

The Junkers Tri-Motor's No. 3 engine shows a typical approach to forcing air through a radial engine.

If you can do all that, you're halfway there. The other half involves letting the air back out, while causing the smallest amount of drag.

Obviously, the outlet should be located in a low-pressure area. Although some cowls vent out the top, most use an opening on the bottom. And many of these openings are much larger than they need to be.

First, it's not sufficient to rely on the pressure (inlet) side to do the work of pumping cooling air through the fins. The outlet should provide some vacuum (lower pressure). By making the outlet side (below the tray) a larger volume than above (or in the plenum), a natural vacuum can often be achieved. The opening itself can be made to help: Many find that a small "lip" bent into the lower trailing edge of the cowl will help create a pressure drop more useful than the drag it creates, like a spoiler on the rear deck of a car. "Small" is the byword!

A potentially more potent pressure-dropper can be made by exploiting the exhaust outlets. Many Reno racers help accelerate the air out of the cowl by "persuading" it with speedy exhaust gases. (The photos do a better job of explaining this.)

In next month's article, look for a few special-case solutions (e.g., pusher/seaplanes) and some traditional and not-so-traditional expedient measures (e.g., cowl flaps, spray bars, and electric fans). Baffling, remember, is simple. Like Mozart's music. EAA

Bill King's Curtiss Pusher replica uses rudimentary "eyebrow" air catchers to put more air on his Lycoming's six cylinders.

Tim Kern is a private pilot who lives near Indianapolis, Indiana. He has written for more than 40 different aviation magazines and also provides writing and marketing services to the aviation industry. He was key builder on two aircraft and has earned the title of Certified Aviation Manager from the NBAA.

Transitioning to Experimental or Unfamiliar Airplanes

Part 2

By Hobie Tomlinson

As we said last month, with the FAA and NTSB stressing the importance of transition training in reducing the amateur-built accident rate, we're concentrating our first Safety Wire columns in *Experimenter* on Advisory Circular (AC) Number 90-109, "Airman Transition to Experimental or Unfamiliar Airplanes," which was published by the FAA's Flight Standards Division (AFS-800) on March 30, 2011.

» To read the entire AC, click here.

Lancair 320

This month we continue by reviewing the transition requirements for Family III and IV airplanes. Family III. Aircraft are characterized as having high inertia and/or low drag. Experimental examples includes Glasairs and Lancairs. Type-certificated examples include the Cirrus SR-22, Cessna Columbia, Piper Comanche, and Mooney M20.

Transition Training for Family III Airplanes – High Inertia and/or Low Drag

1. Defined as airplanes that decelerate slowly when power is removed.

2. A typical accident involves pilots misjudging their approach energy, which in turn causes high, fast approaches with their associated long landings. This results in overruns, or worse yet, attempted go-arounds that occur too late in the landing sequence.

3. Transition hazards:

a. This family of airplanes is on the leading edge of the low-drag design technology. They are beautiful, sleek, and look fast even while sitting on the ground. These airplanes are fast, efficient, and have significant range; however, unless their low-drag characteristics are adequately managed, they will build excessive speed during the critical flight phase of approach and landing.

b. Unmanaged excess speed can result in overshooting the final approach path and descent angle, an inadvertent stall during a much-too-late go-around

Photography by Jim Koepnick

attempt, wheel barrowing, loss of control, and runway excursions.

c. Also included in this family are airplanes designed for high-speed cruise. These airplanes have relatively high stall speeds necessitating high approach and landing speeds. This can be a challenge for pilots transitioning from lower-performance airplanes that will result in long touchdowns, runway overruns, and much-too-late go-around decisions. These airplanes also become challenging when required to follow a slower airplane in the traffic pattern.

4. Recommended training for this family includes both ground training and flight training.

a. Ground training for airplanes in this family should include reviewing the proper power, airspeed operating limits, altitude, and configuration for the specific airplane's approach and landing maneuver. Training should include the proper configuration and adequate speed control for producing a stabilized descent and landing approach. Performance capabilities should be taught so that pilots are aware of the runway lengths necessary for safe airport operations. Decision making on when to reject a landing and initiate a go-around should be taught before flight training begins.

b. Flight training must include descents from cruise altitude, pattern work, and landing distance awareness. Training must include instruction in descent profiles to teach the proper distance versus altitude from which to begin a normal descent profile. A properly planned descent profile should permit the aircraft to descend without large reductions in power and simultaneously prevent overspeeding the aircraft. If the aircraft is equipped with speed brakes, incorporate their correct use into the training. Landing pattern practice should emphasize proper power, correct descent profile, and configuration for the approach and landing phase of flight. Demonstrate the landing distance required for different types of approaches in the various landing configurations. Then practice them until successful repeatability is ensured. There also needs to be an emphasis on adequate control (and a correct understanding) of the airplane's stopping distance.

Fuel systems tend to be complicated on complex and high-performance airplanes.

5. Transitioning to higher-performance airplanes can be demanding for most pilots without previous high-performance airplane experience because of their new flight controls, new systems, and more complex systems. The increased performance and complexity of higher-performance airplanes require additional planning, judgment, and piloting skills. Transition training in these types of airplanes needs to be accomplished in a systematic manner using a structured course of instruction that is administered by a well-qualified flight instructor. This class of airplanes will involve exposure to some, or most, of the following:

a. Turbo-charged engines allow the aircraft to maintain sufficient cruise power at high altitudes where there is less drag, providing higher true airspeeds and increased range. Aggressive and/or abrupt throttle movements will increase the possibility of overboosting (or shock cooling) the engine, both of which will cause severe engine damage.

b. Retractable landing gear systems may operate mechanically, hydraulically, or electrically, or may employ a combination of the two systems. Pilot knowledge of the system, including proper procedures for emergency landing gear extension, is vital.

c. Fuel systems tend to be complicated on complex and high-performance airplanes. This leads to fuel mismanagement, as reflected in the Nall Report that states almost one-third of fuel-related accidents involve fuel mismanagement (i.e. fuel starvation—rather than fuel exhaustion).

d. Performance (aerodynamics) that allow the airplanes to obtain higher airspeeds make them less forgiving than slower airplanes. Since proper energy management is a significant part of flying high-performance airplanes, the student must learn to fly "by the numbers."

e. High-altitude training is required to fly as pilot-in-command (PIC) on any airplane certified for altitudes above FL 250. Not only are there physiological requirements, but there are also aerodynamic and handling considerations that are critical to safety when operating at the airplane's upper altitude limits. This knowledge is invaluable, even when operating at altitudes below FL 250.

f. Turboprop transition involves learning the different engine operating procedures that are unique to gas turbine engines. The turboprop airplane flies and handles just like any other airplane of comparable size and weight; the aerodynamics are the same. The major difference is in understanding the new type engine's operating procedures and its related systems.

g. Jet transition absolutely requires that pilots receive training in the specific type jet from a knowledgeable and experienced instructor. This is due to the jet's performance capabilities, flight characteristics, and more complicated systems. The very best transition training for jet airplanes will be obtained from a recognized training provider using a Level D Full Flight Simulator (FFS). TC'd civil jets require an FAA flight test to obtain the required type rating upon your airman certificate, as well as a 25-hour, mentored, initial operating experience period prior to operating the airplane as PIC.

Family IV Aircraft

Family IV aircraft have nontraditional configurations and/or controls. Experimental aircraft examples include the Long EZ, the Air Cam, and the Breezy. A type-certificated example is the Lake Amphibian.

Lockwood Air Cam

Photography by Brady Lane

Transition Training for Family IV Airplanes (Nontraditional Configuration and/or Controls). A TC'd airplane example is the Lake amphibian.

1. Defined as airplanes whose external configuration is sufficiently different from traditional type certificated (TC'd) single-wing, empennage-mounted tail designs so that they display non-traditional handling qualities. Flight control surfaces are different from the typical elevator-aileron-rudder-engine/prop arrangements and/or flight control systems are different from the typical stick/yoke-pedals configurations.

2. A typical accident scenario would involve a pilot who is unfamiliar with the operation of a crosswind landing gear (e.g. Helio Courier aircraft). When the crosswind gear is "unlocked," the aircraft must be allowed to touch down in a crab. This is so that when the crosswind gear swivels upon touchdown, the aircraft will still track down the runway. (If the aircraft is "de-crabbed" prior to touchdown, with the crosswind gear unlocked, the aircraft will track off the downwind side of the runway, even though its longitudinal axis is parallel to the runway centerline. This is due to the fact that the crosswind will usually provide enough side loads to swivel the landing gear.) Conversely, if the aircraft is landed in a crab with the crosswind gear locked, it will ground loop-- just like any other conventional gear airplane.

3. Discussion of transition hazards are as follows:

a. The external configuration of TC'd airplanes follow a standard pattern using a single wing with ailerons (and usually flaps) and a tail consisting of a vertical and horizontal stabilizer equipped with trailing edge rudder and elevator. Even though there may be variations on the theme (e.g. a stabilator for the horizontal tail component or a "V-tail" configuration using ruddervators to perform both pitch and yaw functions) all TC'd airplanes will behave in an expected, intuitive, and acceptable manner.

b. The innovations presented in the experimental aircraft can include non-traditional configurations and controls, canards (Long-EZ), and wing-mounted pusher engine installations (Lake Amphibians) that produce strong thrust-vector effect. Other non-traditional configurations include flaperons (i.e. drooped ailerons – Robertson STOL conversions) leading edge slats (Helio Courier), crosswind gear (Cessna 195), differential spoilers (MU-2), and all-moving vertical tails (Mooney M20). Cockpit controls may be a yoke, conventional stick, or outboard side-stick. Side-sticks may pivot conventionally, or translate (slide) for pitch while pivoting for roll control. Throttles may be on the left side, right side (or both), in the center, on the floor, or on the ceiling (flying boats). The obvious hazard in all this is the potential for pilot misuse of the controls due to unfamiliarity with the human-machine interface.

c. Issues Specific to Canards are as follows:
(i) While canards offer several aerodynamic advantages, they also carry some unique risks. Because a canard lifts upward (rather than downward like conventional tails), it reduces the load carried by the wing (rather than increasing the wing's load). This upward lift characteristic produces improved aerodynamic efficiency, but also makes its proper aerodynamic design extremely critical.
(ii) The canard must be designed to stall before the wing stalls in order to allow a nose-down pitching moment. If the wing stalls first, while the canard is still producing lift, there is no way to lower the aircraft nose and the stall then becomes unrecoverable (i.e. a deep stall). Additionally, if the canard stalls during the landing flare, the aircraft will be seriously damaged (or worse).
(iii) A canard will typically have a rudder on each swept wing tip, with each rudder only deflecting outward. This feels natural to the pilot and actually helps minimize adverse yaw. Unlike traditional airplanes, both rudders can be deflected simultaneously to act as a speed brake. Because the deflected rudders change the air flow over the outboard wing sections (which are aft of the aircraft's CG),

Long-EZ

deflecting both rudders simultaneously will produce an unexpected pitching moment, as well as typically reducing aileron effectiveness because of the disturbed airflow over the outer wing panels.
(iv) Canards require a dramatic wing sweep to locate the rudders far enough aft on the airframe to be effective. Their dramatic wing sweep causes a strong rolling tendency during any uncoordinated flight. (A strong yaw-roll coupling effect is a characteristic of all swept-wing airplanes.) Whenever a slidslip is produced by rudder usage (or a wind gust), the airplane will weathervane back into the relative wind as well as roll away from the sideslip. (i.e. a "Dutch Roll" tendency which is also characteristic of swept wing airplanes.) During slow flight, this rolling tendency may be more powerful than that which can be countered by the ailerons alone.
(v) Canard's wheel brakes are typically operated by applying force to the rudder pedal after the rudder is fully deflected. This design saves both weight and space, but it means that there is no braking without fully deflecting the rudder. This works well for taxiing, but warrants consideration (and familiarity) for crosswind operations.

d. Other configurations that may cause problems are as follows:
(i) Hand lever operation of the wheel brakes can be found in some earlier Piper Cherokee aircraft that did not incorporate the toe-brake option. Hand brakes require the pilot to release either the stick or throttle control to operate the hand brake lever, and it's your arm strength that determines the braking effectiveness. If brakes are cable actuated (via a single brake lever), cable rigging becomes a critical issue in order to prevent asymmetric brake application.
(ii) High-wing-mounted engine configurations (usually pushers) cause a reverse thrust-vector effect in which increasing power pitches the nose down (instead of up) and reducing power pitches the nose up (instead of down). Although pilots adapt to this effect, it complicates maneuvers such as a rejected landing go-around. Becoming thoroughly familiarity with the airplane's pitch-power interface is essential to safe flight.
(iii) Pilot interface with the control surfaces has a large influence on workload, handling qualities, and overall satisfaction with the aircraft. A short side-stick, which requires a lot of effort to move, will limit maneuverability, and this disadvantage will grow as the airplane's speed increases. Quickly finding the neutral stick position after an airplane upset can also be very difficult with side-stick controls.
(iv) Pilots typically enjoy a tactile reference for their stick arm, usually resting their forearm on their thigh. Side-stick designs, without an arm rest, deprive the pilot of this reference and make fine adjustments difficult, leading to unwanted control inputs during turbulence. In designs with single side-stick between the seats, poor implementation can limit roll control due to interference with the pilot's or passenger's leg.

4. Recommended Training is as follows:

a. Ground training should allow the pilot to become thoroughly familiar with the location, force required, displacement, and operative sense requirement of all the cockpit controls. Know your airplane's systems, limits and recommended procedures before you begin flying. Practice simulated emergency procedures while on the ground. Consult the kit vender, type club members, and other owner/builders of your airplane model for additional information.

b. Flight training recommendations are as follows:
(i) Best training is accomplished in your specific airplane with a well-qualified instructor who is experienced in the specific make and model.
(ii) Second best training source is from the kit vendor, either in your airplane or in their demonstrator of the same model airplane.
(iii) Third best training source is information from and flying with the previous owner, if you purchased your aircraft already built.
(iv) All training should emphasize the unique aerodynamic behavior of your airplane's non-traditional configurations, as well as any pilot compensation required to safely fly the airplane. If any of your airplane's cockpit controls are different from what you are accustomed to, insure that you have become familiar with the advantages and disadvantages of the design. Be sure that you explore your plane's handling qualities under safe, supervised conditions.

The thought for this month is "Not being known doesn't stop the truth from being true." - *Richard Bach*, American author. So, until next month, be sure to Think Right to FliRite. EAA

Hobart C. "Hobie" Tomlinson is the Director of Safety for Heritage Aviation, Inc., in South Burlington, Vermont. He is also a Flight Advisor for EAA Chapter 613. He received the 2012 Spirit of Flight award from the Society of Experimental Test Pilots.. He was also named the 2012 National CFI of the year by FAA.

Phil Knox with the AeroMax built by members of EAA Chapter 132 from a kit donated by the manufacturer. The AeroMax, like its predecessor the AirBike, is flown with the pilot's legs on the outside of the fuselage, similar to a motorcycle.

Welcome to…
The new Light Plane World column

By Dan Grunloh

Welcome to news and commentary from the world of ultralights and light planes. EAA originally adopted the light plane terminology in the early 1980s to describe the mixture of aircraft, including light N-numbered amateur-built aircraft, flying at the time. It didn't take long for the knowledge and skills accumulated in the homebuilt aircraft scene to migrate into the ultralight movement and create "proper little airplanes," as they were called at the time. The original EAA *Ultralight* magazine, which began in January 1981, was renamed *Light Plane World* three years later, and in May 1987 it became *Experimenter* magazine. We still use the light plane terminology on the grounds of AirVenture and in aircraft judging because it best describes the mixture of N-numbered light aircraft flying with the ultralights from the grass strip at AirVenture. We have everything from foot-launched powered paragliders to light-sport aircraft (LSA) like the Flight Design CT flying "down on the Farm." They're all part of the world of light planes.

AeroMax Is Back

This AeroMax displayed at EAA AirVenture Oshkosh 2012 by Phil Knox, president of EAA Chapter 132 in Elkhart, Indiana, was built by chapter members and brought with it some good news. The aircraft is built with laser-cut plywood parts using a locking tab technology that speeds construction and eliminates the need for jigs and fixtures. Learn more about the development of the aircraft in the story "JDT AeroMax Prototype Flying in Tasmania," published in the February 2011 issue of the *Light Plane World* e-newsletter. Unfortunately, JDT Mini-Max closed its doors earlier this year when the U.S. partner in the firm, John Grabber, announced his retirement. The engineering and design side of the company is based in Australia, and without a U.S. partner for manufacturing and distribution, there would be no AeroMax kits.

Australian partner David Trump came to the United States for a meeting with many of the original players in the company, including those associated with production of the parts and kits for the JDT AeroMax. Phil Knox owns the tool and die company used for fabricating the metal parts and laser-cutting the wood components. JDT Mini-Max has now been reorganized as TEAM Mini-Max LLC, a name that harks back to the roots of the design. The international company includes partners from South Africa and China. They have brought on board some of the original TEAM (Tennessee Engineering and Manufacturing) personnel, including Larry Israel. Their new website, www.TeamMini-Max.com, has more details, a history of the TEAM aircraft designed by Wayne Ison, and a surprising announcement.

TEAM Mini-Max hopes people will download the plans, start building, and then be motivated to buy parts and kit components that can be ordered through the website.

The company is making the plans for all of the TEAM airplanes (seven models) available free of charge as a PDF download from its website. TEAM Mini-Max hopes people will download the plans, start building, and then be motivated to buy parts and kit components that can be ordered through the website. The AeroMax is a laser-cut kit, and plans are not needed or available. David Cooper, director of U.S. operations in Niles, Michigan, said the company also plans to reengineer one of the earlier classic Mini-Max models as a laser-cut kit.

Oratex Fabric on Bodacious

When I first saw the new prepainted fabric covering on Bodacious,

John Steere's Bodacious started out as a Legal Eagle, but so many major changes were made that it became a different airplane. It's shown here with the wings folded, another of its unique features. The prepainted fabric colors are Cub yellow and Fokker red.

the AirVenture Reserve Grand Champion ultralight by John Steere of Martinsville, Indiana, I thought it was one of the top news stories in the ultralight area. The unique plane, inspired in part by Leonard Milholland's Legal Eagle, showed fabulous workmanship and much originality. See more photos by Mathew Long here. Oratex UL600 is a prepainted woven fabric that uses the same technology that has been available for years for model airplanes, but it is now engineered for full-size aircraft. The red and yellow colors looked terrific.

Oratex UL600 is approved for aircraft up to 600 kilograms or 1,320 pounds gross weight. It is glued to the airframe with a water-based adhesive, then the fabric is shrunk tight with heat, and you are done. There are no paint runs, painting equipment, or hazardous solvents, and the method will save both time and weight. Oratex has a finished weight of 3.0 to 3.8 ounces per square yard and should save 10 to

I would argue it makes little sense to include the full 5 gallons of batteries in the empty weight of the ultralight.

20 pounds of weight per airframe. The final cost is said to be about the same as conventional aircraft covering processes after you consider the cost of aircraft paints. Unfortunately the range of colors is small. For more information, go to the German manufacturer's website, Oracover.de. The UK distributor has a summary here, and there is a dealer for Alaska and Canada at www.BetterAircraftFabric.com. Expect the announcement of a U.S distributor soon.

Batteries as Fuel

Something significant happened at AirVenture, and you might have missed it unless you talked to Dale Kramer or noticed he brought his eLazair electric-powered ultralight to AirVenture 2012 in the landplane version. The ultralight no longer qualifies for the additional 60-pound "allowance" for amphibious floats as it was when flown here last year. It now must weigh under 254 pounds empty of fuel. There has been some talk and

Dale Kramer with his electric-powered eLazair, now in the landplane version, returned for a second year of flying at AirVenture. It will fly for about one hour per charge. The ultralight was probably the most flown electric airplane at the convention.

Darrell Porter showed off his craftsmanship to bystanders down in the ultralight area with his wood and PVC replica Spandau machine gun for replica light planes of the First World War. The only thing missing was a sound effects machine.

discussions about a weight allowance or exemption for the batteries in electric-powered ultralights, and now thanks to Dale, we can better understand the argument that batteries are the fuel and should not be included in the empty weight.

There were some lively discussions in front of his plane with people who thought differently, but Dale reminded everyone there is no weight limit on the fuel allowed for ultralights. The maximum amount is 5 gallons in volume, and there is no limit on the type of fuel. It could be gasoline, corn oil, solid rocket fuel, peanut butter, or electric batteries; so long as it fits in 5 gallons. Batteries are different from other types of energy sources in that their weight is the same whether empty or full. I would argue it makes little sense to include the full 5 gallons of batteries in the empty weight of the ultralight. Dale apparently feels confident enough of his analysis of the question that he made many flights at AirVenture in his eLazair, which weighs about 300 pounds with 5 gallons of batteries, but much less than 254 pounds without any fuel or other energy source.

Mock Machine Gun for Ultralight or Light Plane

Airplane and model builder Darrell Porter showed his very realistic mock German Spandau machine gun at AirVenture 2012 in the ultralight area. Darrell built it for his own World War I Fokker replica, which was displayed in the replica fighter area. He works for Robert Baslee, designer of the Airdrome Aeroplane designs based in Holden, Missouri. Darrell didn't like the "toy" machine guns offered for use on the Baslee replicas, so he decided to do it better. A kit will be sold through Robert Baslee and Airdrome Aeroplanes. The materials are wood, PVC, and metal, and much of the work is already completed. The price has not yet been determined. It's not on the website yet. If interested, call and ask. The company manufactures kits for quite a few replica airplanes, including a three-quarter-scale Eindecker ultralight ($5,495 less engine and paint). Learn more at www.AirdromeAeroplanes.com.

Powered Parachute for Your Bucket List

I have a confession to make. Although I have been an airman for 30 years and consider myself to be a well-rounded aviator, somehow I had never gone for a flight in a powered parachute. It wasn't because I didn't like them—and I had many opportunities—but most of the time I was flying something of my own. At fly-ins, I didn't want to take a seat away for a newcomer who might decide to take up flying. The years kept slipping by, and I was still a powered parachute "virgin."

Finally, a recent introductory lesson with a certificated instructor in an LSA powered parachute has given me a better understanding of their charm and appeal. During the takeoff roll I was struck by the extremely powerful pull of the canopy as it swung overhead. In cruise flight I came to the conclusion that few ultralight pilots, aside from those who flew the early designs, have actually experienced this degree of slow, open-cockpit flight. Many of us can slow our ultralights, trikes, or fixed-wing light planes down to 30 mph or less, but this is completely different. We are not hanging on the edge of a stall, delicately controlling pitch and throttle while keeping the wings level and ensuring we have plenty of altitude for stall recovery. The powered parachute experience is far more relaxed.

If I wanted to buy a first open-cockpit airplane experience for my spouse or another relative, this would be it. You should try it, too. It's hard to imagine anyone going up for a ride in a powered parachute and not wanting to get back in the air again in some type of aircraft (as Leonardo da Vinci once said). Next up for me is a gyroplane like those shown in this video from the 2012 Popular Rotorcraft Association Convention in Mentone, Indiana. EAA

If you have thoughts or suggestions for this column, please send your comments to dgrunloh@illicom.net.

Dan Grunloh, EAA 173888, is a retired scientist who began flying ultralights and light planes in 1982. He won the 2002 and 2004 U.S. National Microlight Championships in a trike and flew with the U.S. World Team in two FAI World Microlight Championships.

Dan Grunloh grinning during his first flight as a passenger in a powered parachute in Kankakee, Illinois, in August.

Airspeed Basics

By Ed Kolano

I once had the privilege of flying an airplane that did everything at about 130 knots. Big deal, you say, because you've probably had that privilege yourself. The difference with this airplane was I did it somewhere on the other side of 60,000 feet. That put the true airspeed around 480 knots. Don't plan to fly that high? Doesn't matter.

Understanding airspeed is essential if you want to know – and you do – your airplane's best climb speed, maximum range cruise speed, and just in case, its maximum range glide speed. To get there, you'll need to perform flight testing, and that involves a lot of work with airspeeds. Last month we identified the various *kinds* of airspeeds pilots should be familiar with. This month we'll get into the details. That'll put us in a good position to move on to calibrating your pitot-static system, which you'll have to do before you start collecting the data that will eventually become the performance charts in your airplane flight manual.

There are five airspeeds to deal with. They are:

1. Observed
2. Indicated
3. Calibrated
4. Equivalent
5. True

We're going to examine each of these airspeeds by themselves, then put the puzzle back together.

Observed and Indicated Airspeed

Observed airspeed is what you see on the airspeed indicator. I know, you thought this was indicated airspeed. Well, it is according to FAA publications and many pilot's operating handbooks. There's no harm in doing this, because these manuals just want you to be aware of the difference between what you see on the airspeed indicator and

Calibrated Airspeed	Equivalent Airspeed			
100	100	100	100	100
150	150	150	150	149
200	200	200	199	197
300	300	299	297	292
400	400	397	393	383
	Sea Level	5K	10K	20K

Table 1

the published calibrated airspeeds. You use calibrated airspeed in your true airspeed calculations, so the airplane manufacturer wants to ensure you know what you read on the airspeed indicator may have to be adjusted before you perform any planning.

We're differentiating between observed airspeed and indicated airspeed because the airspeed indicator itself may not be completely accurate. FAA airworthiness standards for small airplanes call for minimum instrument calibration error. This is the error inherent in the gauge itself. Indicated airspeed is observed airspeed corrected for airspeed indicator internal errors. You can have your indicator bench-tested to determine any errors between what the airspeed indicator reads and what it should read based on the pitot and static pressures applied to it during the bench test. You've probably seen articles explaining how to do this with a simple water manometer used to apply air pressure to the airspeed indicator. The applied pressures correspond to appropriate airspeed readings. The technician compares the appropriate indicated airspeeds with the readings observed on your airspeed indicator. Once you know these errors, you can correct what you read on the airspeed indicator (observed airspeed) to what it should read (indicated airspeed).

Indicated airspeed is observed airspeed corrected for airspeed indicator internal errors. *Note: Some texts refer to what you read on the gauge (what we're calling observed airspeed) as indicated airspeed and the airspeed corrected for indicator internal errors (what we're calling indicated airspeed) as true indicated airspeed. Too much of an opportunity to confuse it with true airspeed, so we'll stick with observed airspeed.*

You've probably seen articles explaining how to do this with a simple water manometer used to apply air pressure to the airspeed indicator.

Indicated and Calibrated Airspeed

The observed-to-indicated bench test is accomplished by applying specific pitot and static pressures to the respective fittings on the back of your airspeed indicator. These same fittings are used to connect your airspeed indicator to your airplane's pitot and static lines that go to your airplane's pitot tube and static ports. These lines route the air pressure sensed at the pitot tube and static sources to your airspeed indicator. Unfortunately, the pressures sensed at the pitot tube and static sources are not always the real ambient pressures, and an in-flight calibration is necessary to account for these errors.

Although it's a common belief that the errors are mainly due to the pitot tube not being oriented directly into the relative wind, for example, during slow flight or high angle of attack flight, most of the problem comes from the static side of the system. Static ports are generally along the side of the fuselage or pitot tube. The object is for these ports to be exposed to the ambient air pressure without allowing any ram pressure to enter. Ram pressure is pressure caused when air is forced into the port by virtue of the airplane's forward speed. It's the pitot tube's job to sense that ram pressure along with the ambient pressure, but the static port should be located such that it senses only ambient or static pressure. This is why the static port is located where its opening is perpendicular to the relative wind.

Because your airspeed indicator compares the pressure from the pitot tube with the static pressure, any variation in sensed static pressure can cause erroneous airspeed indications.

Different flight conditions and landing gear and flap positions can cause the air pressure around the static port to vary. Because your airspeed indicator compares the pressure from the pitot tube with the static pressure, any variation in sensed static pressure can cause erroneous airspeed indications. The only way to determine these errors is through flight testing.

We'll discuss flight-test methods next month, but for now we'll just make the point that calibrated airspeed is indicated airspeed corrected for errors stemming from the pressure variations around the static port. *Note: Certified airplane manufacturers perform extensive testing to find a static source location or position on their airplanes where this variation is minimal. That's why this indicated-to-calibrated correction is often called position error correction or installation error correction.*

Calibrated and Equivalent Airspeed

Equivalent airspeed is calibrated airspeed corrected for compress-

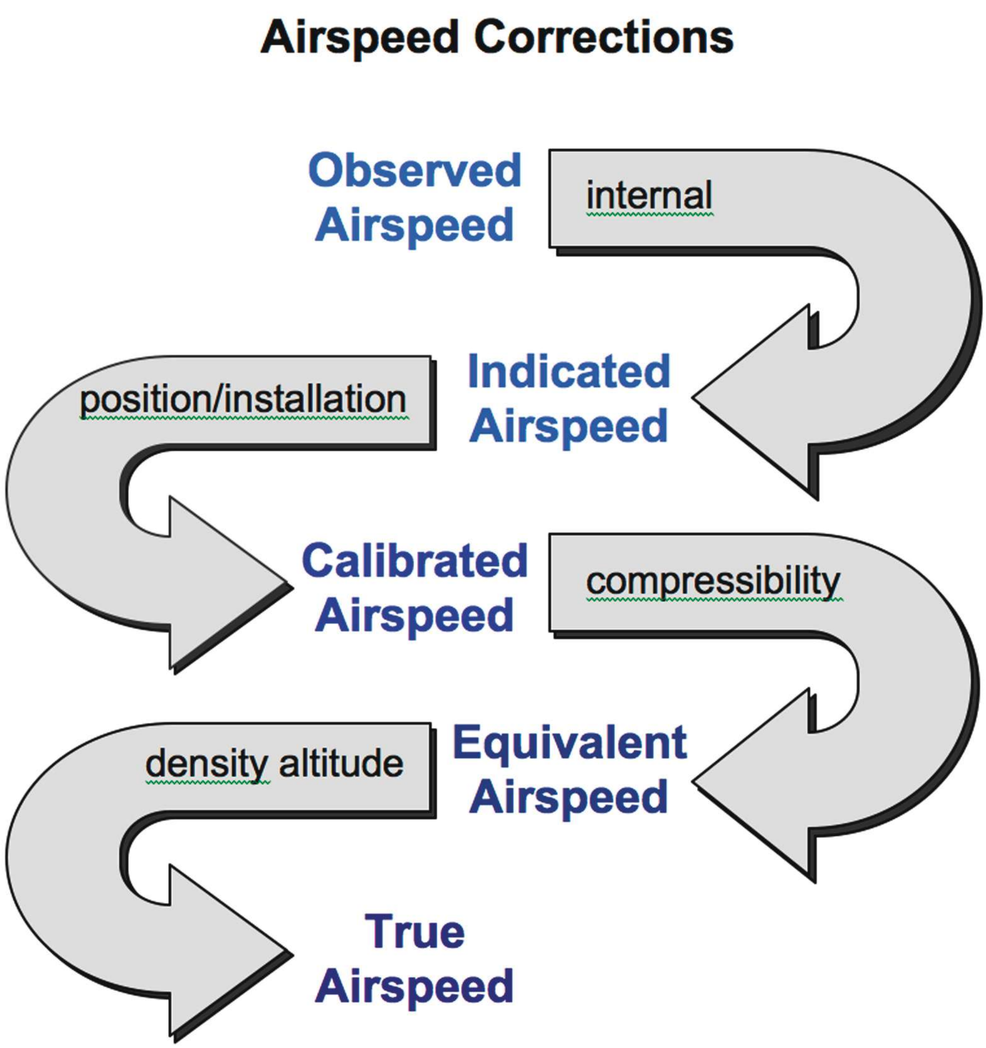


Figure 1

ibility. This word "compressibility" is often associated with high-speed, near-sonic flight, but in this application it has to do with the air pressure in the pitot system. In a nutshell, at faster speeds and higher altitudes, the static pressure sensed in the pitot system (remember, the pitot system senses total pressure or static plus dynamic pressure) is not the true static pressure. The sensed static pressure is higher due to this compressibility effect, so the total pressure in the pitot system is artificially high. This causes the airspeed indicator to show a faster speed than the airplane is actually flying.

The good news for most of us is we usually don't fly fast enough or high enough to worry about correcting for this error. Table 1 shows the corrections that would have to be applied to a sampling of calibrated airspeeds at different altitudes. Unless you fly faster than 200 knots calibrated airspeed higher than 10,000 feet pressure altitude, you can probably safely ignore this correction. *Note: The manufacturer calibrates the airspeed indicator to read correctly under standard day, sea level conditions, so there is no calibrated-to-equivalent correction necessary when flying under these conditions at any speed.*

Equivalent and True Airspeed

The higher you fly, the less dense the air is. This decrease in air density affects the pressure sensed by the pitot system, and therefore, the reading on your airspeed indicator. Say you fly your airplane at 100 knots equivalent airspeed at sea level. The pressure in your pitot system causes your airspeed indicator to read 100 knots. (Let's assume the corrections for indicator, position, and compressibility errors are zero for simplicity.) If you fly your airplane at 100 knots equivalent airspeed at 10,000 feet, the less dense air means a lower sensed pressure in the pitot system, and that results in a lower airspeed reading on your airspeed indicator. Alternatively, if you fly your plane at 10,000 feet with an airspeed indicator reading of 100 knots, your true airspeed will be faster.

The sensed static pressure is higher due to this compressibility effect, so the total pressure in the pitot system is artificially high.

You may be familiar with airspeed indicators that have true airspeed indicating capability. Rotating a temperature scale to align outside air temperature with your pressure altitude on a pressure altitude scale also rotates a true airspeed scale behind the indicating needle, allowing you to read true airspeed directly along with observed airspeed. This simple device works because aligning the outside air temperature and pressure altitude scales compensates for density altitude. Density altitude is pressure altitude corrected for temperature. True airspeed is equivalent airspeed corrected for density altitude.

True Airspeed and Ground Speed

Ground speed is true airspeed corrected for wind. This wind correction is learned by every private pilot and used by every pilot every time we fly. Although ground speed has nothing to do with your airplane's airspeed indicating system, it completes our look at the flight speed picture.

As Figure 1 shows, what you read on your airspeed indicator is observed airspeed. Correct the observed airspeed for internal gauge errors, and you get indicated airspeed. Correct the indicated airspeed for installation/position errors to get calibrated airspeed. Account for high-speed and /or high-altitude flying to find equivalent airspeed. Correct equivalent airspeed for density altitude to find true airspeed. Apply wind corrections to your true airspeed to determine ground speed.

If all these different airspeed corrections sound intimidating, take heart. If your flying habits or airplane limitations keep you below the equivalent airspeed correction altitudes and airspeeds, you'll need just two tests. The manometer bench test will account for any errors in the gauge, and an airspeed calibration flight test will take care of any installation errors.

Okay, we've laid the groundwork with this airspeed primer for next month's topic – airspeed calibration. We'll take a look at a few flight-test methods you can use to identify your airplane's position error corrections.

Questions about flight testing? E-mail experimenter@eaa.org; please put "Flight Testing" in the subject line. EAA

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EAA Employee Brian Tesch #849155 wearing Camp Shirt
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