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On the cover: SAM Aircraft's SAM LS photographed by David Leininger over Oshkosh, Wisconsin.

LETTERS

EDITORIAL@KITPLANES.COM

Timing Magnetos

Dave Prizio's article on external timing of magnetos (October 2013) provides a very good description of the process. However, I may be able to add a couple of twists to Dave's process as a result of 45 years experience as an A&P/IA.

When connecting the mag timing equipment, initially connect only the L/H leads to the L/H magneto. Turn the ignition switch to the "L" position. Proceed with the timing process described by Dave. If you can check the timing, the switch is connected correctly. This little extra step can save untold hours of diagnostic effort. I have lost track of how many aircraft I've inspected with the "P" leads crossed.

The vast majority of aircraft piston engines only have an impulse coupling on the L/H magneto. Most key ignition switches, when placed in the start position, will ground (turn off) the right magneto. This is done to prevent the R/H magneto, with the timing typically set at 25 degrees before top dead center (BTDC), from firing the spark plugs at very low starting RPMs, causing kick-back and hard starting. If your engine will crank and then start at the moment you let go of the key, you may have crossed "P" leads.

While moving the propeller in the direction of rotation during the timing check process, bring the propeller forward to just two or three degrees shy of the mark. At this point, use the palm of your hand to carefully tap the propeller forward at the trailing edge of the very tip. With very little practice, you will be able to make ¼-degree changes resulting in a very accurate timing check.

When new mag gaskets are installed, I have always used a product called Tite Seal (Light Weight). Apply a thin coat on each side of the gasket. This stuff is sticky and will assist in keeping the gasket on the mag during installation. Tite Seal does not harden, staying soft for a very long time. You will be able to make many adjustments to your mag timing and not damage the gasket.

I hope I have added a little to an otherwise excellent article.

DANA HALL

Dave Prizio responds: Dana makes some good suggestions. They add an important point of view to the topic. It is important to be sure that the P-leads go to the correct magnetos. When working on a large number of unfamiliar airplanes, it is good practice to check this every time.

I also have no quarrel with using a non-hardening gasket sealer on the magneto gaskets. I do not verify P-lead wiring every time because I work on a relatively small number of familiar planes, most of which I helped build. I also have a general aversion to gasket sealers unless there is a specific need for them, but there is no doubt that sometimes there is such a need. I think these minor differences in our personal preferences mainly reflect the different shop environments we have experienced.

Wire Lacing Tip

Very informative article (October 2013), but how come you specify a granny knot instead of a square knot?

WILLIAM GROHOSKI

Paul Dye responds: I prefer a granny because the purpose of the more elegant square knot is to allow it to trip, given a quick tug on one ear. We don't want this securing knot to trip, so I use a granny. +

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EDITOR'S LOG

Old school.

Although the title of our magazine is KITPLANES®, we hope the tagline, "Your Homebuilt Aircraft Authority," answers the question, "But what if I'm building from plans? Is this magazine for me?"

Our goal at KITPLANES® is to live up to that tagline—we want to cover and embrace the entire homebuilt aircraft community, including those who start their dreams of flight not with a kit in a large set of boxes, but with an Aircraft Spruce (ACS) or Wicks catalog open to the pages of raw materials: steel tubing, sheet aluminum, fiberglass cloth, and (the old favorite) aircraft-quality Sitka spruce.

When I was young and just beginning my career as a hangar rat, the first airplane I put my hands on was an old L-4 that we were converting to J-3 status as we rebuilt it from the bones up. It had these lovely wooden spars, carved from the heart of a Sitka spruce. I was taught that this was the wood of choice for flying machines: straight grained, consistent, flexible, but strong. I remember those spars even today—beautiful, better than fine furniture. We took off all the ribs, sanded them down, varnished them, and then began the loving task of returning them to flight. That airplane suffered a crash a few years later that bent the fuselage pretty badly—but I understand that the wings might still be hanging in a loft somewhere, and I hope that those spars are waiting to once again be returned to flight by another set of varnish-covered hands.

Building an airplane from scratch is a grand old tradition that goes back a very long way—well before the Wright brothers in fact. Whether you start with your own ideas, or plans drawn by others, constructing a flying machine in this fashion connects you to those generations that have gone before, bonding you to them through a shared history. I remember the first time I saw the big ACS catalog with all of those raw materials. The best part was up front—those pages of plans and material kits that set you dreaming about what to build. Kit builders often customize their airplanes, but plans builders make fundamental changes from the very start. So long as you obey the laws of physics and aerodynamics, you have the freedom to build the flying machine of your dreams.

I'd wager that the majority of new Experimental aircraft licensed each year in the United States are built from kits—yet plans- and scratch-built machines still emerge from shops and garages with regularity. It takes the average builder a lot longer to produce such machines, but to those who go that direction, it is all worth it.

This month, we present a survey of the plansbuilt world in our annual Buyer's Guide. As with our Kit Buyer's Guide from last month, the true database is online for your continued examination and perusal. Let these pages whet your appetite for exploring the many aircraft listed in our guide—the online version will allow you to compare and contrast as you settle in on your choice. If plans-building is in your future, we wish you the best of luck and will continue to support your efforts with articles on techniques and products that will see you through. KITPLANES® is about more than kits—it is a support system for anyone that wishes to leave the earth on wings they have built themselves.

Thirty Years

You might have noticed that our cover this month recognizes KITPLANES®' 30th year of publication. Although my history with the magazine is fairly short, I continually look back at the pages of years gone by and see names that repeat themselves—expert builders and writers that have shared their experience over the years. Our history is important, for it drives our future—and in the coming months, we hope to resurrect a few memories of airplanes and people that have come before. Some will make you chuckle, some will make you think, and we hope that all will inspire.

KITPLANES® is here to inspire you and keep you going through the build—and beyond. We're not just about building, we are also about flying, and doing so with good risk trades that will allow our readers to continue flying without incident for many years to come. Stick with us as we look back at the past on occasion, and don't forget: we survive on the contributed wisdom of our readers. We're always looking for good stories—and we'd love to publish yours! ✢

Paul Dye

Paul Dye retired as a Lead Flight Director for NASA's Human Space Flight program, with 40 years of aerospace experience on everything from Cubs to the space shuttle. An avid homebuilder, he began flying and working on airplanes as a teen and has experience with a wide range of construction techniques and materials. He currently flies an RV-8 that he built in 2005 and an RV-3 that he recently completed with his pilot wife. A commercially licensed pilot, he has logged over 4500 hours in many different types of aircraft. When not writing on aviation topics, he consults and collaborates in aerospace operations and flight testing projects.

FLIGHT REVIEW

SAM LS

Retro look for fun flying.

BY KEVIN HORTON

The LSA Aircraft market is starting to look a bit crowded to these eyes, with many dozen aircraft types. There are a few popular classes of aircraft, with a rather large number of composite, high-wing, side-by-side, tricycle-landing-gear types, and numerous tube-and-fabric, high-wing, tail-dragger, Cub-like types. Both categories have some popular models, but woe to any new manufacturer who hatches a similar new bird. It would have to be a real peacock to stand out in that crowd.

SAM Aircraft wisely chose to produce something different, all the easier to be noticed. The SAM LS is inspired by the Ryan STA (a gorgeous, low-wing, tandem-seating taildragger from the 1930s), but the prototype has tricycle landing gear so it looks more like a smaller Varga Kachina than it does the Ryan.

Romantic Inspiration

SAM Aircraft hails from Lachute, Quebec, about a 45-minute drive NW of Montreal, but the company has its roots across the pond in France. Company founder Thierry Zibi learned to fly at La Ferte-Alais Aeroclub, just south of Paris. La Ferte-Alais is best known for the annual airshow highlighting classic, antique, and warbird aircraft. After learning to fly, Zibi got the bug to design his own aircraft, and was attracted to some of the classic monoplanes from the era between WW-I and WW-II.

Thierry was especially smitten with the Ryan STA; and when he finally saw one in the flesh, he knew he had found the inspiration for his design. But if he wanted to market his aircraft, it had to fit into the available regulatory frameworks. The ultralight category in France was popular, but the maximum take-off weight (992 pounds) would be a serious impediment. The situation was much better in North America—Advanced Ultralight Aircraft (AULA) in Canada

and Light Sport Aircraft in the USA had maximum takeoff weights of 1232 pound and 1320 pounds respectively. The Quebec government views aviation as a generator of economic activity, so they offered financial assistance if SAM Aircraft was established there. Decision made—in 2009 Thierry moved to Montreal, Canada's aviation hotbed, with Bombardier, Bell Helicopter Canada, Pratt & Whitney Canada, and many dozen smaller companies in the area.

Once in Montreal, Thierry made contact with several engineers, managers, and technicians with extensive experience in the aviation industry, who were able to assist in turning his concept into a design, and finally a real aircraft. The prototype was built to meet Canadian AULA design standards, as this provided a proven market, and was close enough to LSA to facilitate eventual approval in that category.

The Aircraft

All aircraft are compromises, to one extent or another. Want to go really fast? That drives you to a light aircraft, with minimal wing area and a large engine, which means a tight cockpit, reduced baggage space, etc. The reduced wing area will lead to a higher stall speed and increased takeoff and landing distances. Want a roomy cockpit and lots of baggage area? That leads to a larger fuselage, a higher weight, which requires a larger wing, which means even more weight, which leads to an even larger wing, etc. The resulting aircraft will have a slower cruise speed than the one optimized for high speed.

The art of design is about balancing the various compromises to achieve a resulting product that best meets the needs of the target market. SAM Aircraft has chosen a different set of compromises than many other aircraft aimed at the LSA market, which means their aircraft will answer a slightly different set of market needs than much of their competition. Have they chosen wisely? The only true answer to that question can come from the response of the market. All we can do at this stage is shed some light on the various choices SAM has made, and the effect these choices had on the aircraft.

Choose Your Wing…

The aircraft was designed from the very start to have several variants. The fuselage, tail, and wing center section are common between all variants. The outer wings and landing gear differ. Eventually there will be three different wingspans, the landing gear can be either tricycle or tailwheel, and the aircraft can have a full canopy or an open cockpit with windscreen. If the full canopy is purchased, it can be quickly removed and reinstalled to convert back and forth to the open-cockpit configuration. The prototype has the mid-length wings (28-foot 7-inch span), tricycle landing gear, and a canopy (Winters are cold in Quebec!).

Thierry Zibi is very proud of his attractive baby, the SAM LS.

This wing is stressed for up to 4 G flight load (6 G ultimate load, with 1.5 factor of safety) at 1320 pounds gross weight, and 3.6 G flight load at 1450 pounds. The next variant will be the SAM CC with a shorter 25-foot 3-inch wingspan. The final variant will be the SAM STOL, with a longer 31-foot 10-inch span, stressed for 1320 pounds.

The wing center section was designed for the loads imposed by the worst case of the various wingspans, and the tail was also sized to provide adequate stability and control for the worst-case variant. This means that the other variants are carrying a bit of extra weight that would not be required if the design had been fully optimized for each. The flip side of this compromise is that the parts commonality between variants should result in increased economies of scale and reduced unit costs.

The aircraft has very attractive, classic lines.

Photos: Kevin Horton and David Leininger

The right-hinged canopy provides good access to both seats. The design has been updated since this photo to include two shoulder straps on each seat.

The aircraft is boarded using the fixed step mounted in front of the left wing.

The aircraft was designed to meet the LSA requirements when fitted with the long- and mid-length wings. But SAM Aircraft has not yet submitted the design for LSA approval. SAM Aircraft will submit the design for LSA approval once there is market demand for an SLSA or ELSA aircraft. The aircraft is marketed as an amateur-built kit, stressed and tested for up to 1450 pounds gross weight. The aircraft meets the U.S. Sport Pilot requirements if the builder declares a 1320 pound gross weight. The SAM LS has also received approval under the Canadian AULA requirements at a 1232-pound gross weight. However, an AULA approval leaves only a 402-pound useful load, based on the 830-pound empty weight of the prototype aircraft (without wheelpants), which makes it effectively a single-place aircraft, unless both occupants are quite light.

. . .and Choose Your Look!

The aircraft is designed to be built with either tricycle or taildragger landing gear. This decision should be made before the aircraft is constructed, as it would be a significant task to convert a completed aircraft from one to the other due to the way the main landing gear is attached to the wing center section structure. The prototype has tricycle landing gear, but SAM hopes to convince a local builder to construct a taildragger soon, so this variant can be assessed.

The robust-looking main and nose landing gear legs are fabricated from large-diameter steel tubes which use nylon inserts to provide low friction for the telescoping action. Bungee cords provide the shock action. The hydraulic Matco brakes are controlled by conventional toe brakes on the front seat rudder pedals. Nosewheel steering is via the rudder pedals, with a spring bungee to provide an appropriate amount of give between rudder pedals and nosewheel.

The forward fuselage contains a 4130 steel protection cage that extends from the firewall to just behind the rear seat. The protection cage carries the structural loads in this area, and also protects the occupants in the event of an accident. Aluminum bulkheads are attached to the protection cage to

The Kit

The SAM LS kit includes everything required to build a flying aircraft except engine, propeller, instruments, and avionics. An optional Rotax 912 installation kit is available that includes engine mount, exhaust system, muffler, heating muffler system, propeller and spinner. The 4130 roll protection cage is delivered welded and corrosion protected. The fiberglass fuel tanks are assembled and leak tested by SAM.

All aluminum parts are cut to shape with rivet holes on a CNC machine, and all required bends are already completed. Rivet holes are pre-drilled—80% of these are matched hole, and the other 20% are pilot holes that must be redrilled by the builder to final size. The matched holes allow most parts to be Clecoed together right out of the box, minimizing the requirement for jigs and ensuring that the final assembly is straight and true. All welding is already done. The builder has no parts to fabricate except for some minor modifications to the aileron and flap brackets. The builder "only" has the assembly tasks to perform (anyone who has built an aircraft knows that just the assembly tasks will require many hundred hours).

A large flat table is required to assemble the kit, as are two vertical posts to support the wingspars during construction. All structural rivets are Avdel Avinox pulled rivets, except for 5/32-inch solid rivets in the main wingspar, which can be set with a rivet gun or rivet squeezer, or the builder can order the spar already assembled for an extra $1300. SAM claims a build time of 900 hours for a new builder, and this is probably realistic, except for those over-analytical types who spend most of their time comparing 10 possible ways to do every task so they can choose the best one, then end up buying new parts and doing it all over again because it didn't turn out absolutely perfect. You know who you are!

The skins are 2024-T3 aluminum: 0.020-inch thick for most fuselage and wingskins, and 0.016-inch thick for the control surfaces. The bulkheads vary in thickness from 0.016- to 0.050-inch, depending on the loads they must carry. Some secondary structure is made from 6061-T6 aluminum. The cowling, wheelpants, wingtips, empennage tips, etc. are fiberglass from molds with a marine UV-protection gel coat.

—K.H.

support the aluminum skin. The rear fuselage, wings, and tail surfaces are semi-monocoque aluminum structures. A baggage stowage area extends the full width of the forward fuselage, above the rudder pedals, and is accessed via a hinged door on the left side.

Ailerons and elevators are controlled by front- and rear-seat control sticks via pushrods and bellcranks. Front- and rear-seat rudder pedals are connected to the rudder via cables. Electric elevator trim is controlled by a rocker switch on the control stick. Electrically-powered flaps are controlled by a switch on the left side of the instrument panel. The switch is well placed so that it is reached with minimal movement of the left hand from its natural position on the throttle.

The prototype has a 98-horsepower Rotax 912S, which is mounted on a long engine mount, way ahead of the firewall. The aircraft was designed so that a heavier engine, such as a Lycoming IO-233, could be used on a shorter engine mount. Mounting the heavier engine farther aft would help keep the empty CG in the right place. The cowling has a constant cross section near the aft edge, so it will still fit the firewall if it has to be trimmed to accommodate an engine on a shorter mount.

There is an 11-gallon fiberglass fuel tank in each wing, mounted between the front and rear spars, giving 22 gallons total capacity. One gallon per side is only usable in straight and level flight due to the flat bottoms on the fuel tanks, so the usable fuel is 20 gallons. The fuel selector on the lower left side of the cockpit has left, right, and off selections. An electric boost pump and an engine-driven mechanical fuel pump provide fuel pressure for the two carburetors. A small orifice in the fuel distribution manifold between the mechanical fuel pump and the carburetors allows some fuel (and any fuel vapor) to return to the left fuel tank. Thus if the tanks are full, some fuel should be used from the left tank first to make room for the returned fuel. If the flight plan requires using most of the available fuel, the right tank should be emptied first, so the return fuel is going back into the active tank at the end of the flight.

The prototype has a single 10-inch Dynon SkyView EFIS on the front instrument panel for primary flight instruments and engine instruments. The SkyView is supplemented by a round-dial airspeed indicator, altimeter, VSI, turn coordinator, and magnetic compass. The Dynon transponder is controlled via the SkyView, and the com radio is a Garmin SL40.

The prototype has an empty weight of 830 pounds, but it does have relatively heavy leather seats and armrests, and both EFIS and backup analog instruments. SAM Aircraft calculates that a more spartanly finished aircraft would be

The instrument panel provides lots of room for typical VFR flight and engine instruments.

The Company

SAM Aircraft epitomizes a company that understands one key to long-term survival is to keep costs under tight control. To that end, they only have two full-time employees, plus a number of experienced aeronautical engineers and a test pilot available as required on a contract basis. All kit aluminum and steel components are defined as electronic CAD files using SolidWorks and will be fabricated by other companies on contract, when needed, avoiding the requirement to purchase expensive production equipment and hire staff to run it. SAM Aircraft is based in a modest two-bay hangar on the Lachute airport (CSE4).

—K.H.

SAM LS

Standard Kit (without engine, propeller, avionics, or instruments) ..... $29,000 ($23,200 until spring 2014)
Quickbuild Kit (without engine, propeller, avionics, or instruments) ..... $41,800 ($33,440 until spring 2014)
Estimated completed price ..... $68,850 ..... ($61,680 until spring 2014)
Estimated build time: ..... 900 hrs
Estimated build time with Quickbuild Kit: ..... 500 hrs
Number flying (at press time): 1
Powerplant: ..... 98 hp Rotax 912S
Propeller: ..... Sensenich 70" ground adjustable

AIRFRAME

Wingspan ..... 28 ft 6 in
Length ..... 21 ft 4 in
Wing area ..... 137.8 sq ft
Maximum gross weight (Sport Pilot) ..... 1320 lb
Maximum gross weight (Amateur-Built) ..... 1450 lb
Load factor limits (at 1320 lb) ..... +4G, -2G
Empty Weight ..... 810 to 830 lb
Useful load (Sport Pilot) ..... 490 to 510 lb
Useful load (Amateur-Built) ..... 620 to 640 lb
Usable fuel quantity ..... 20 gallons

PERFORMANCE*

V_{NE} ..... 155 mph IAS
Maximum cruise speed ..... 125 mph TAS
Range at maximum cruise speed ..... 500 statute miles
Rate of climb at 1320 lb ..... 710 ft/mn
Rate of climb at 1450 lb ..... 600 ft/mn
Take-off ground roll ..... 350 ft
Landing ground roll ..... 350 ft
Stall speed with full flap ..... 42 mph IAS
Stall speed with flaps up ..... 49 mph IAS

**Specifications are manufacturer's estimates and are based on the configuration of the demonstrator aircraft. Your mileage may vary.*

The three canopy hinge bolts can be quickly removed to put the aircraft in an open cockpit configuration.

approximately 20 pounds lighter. With an empty weight of 810 to 830 pounds, the aircraft can carry 358 to 378 pounds of occupants and baggage, plus full fuel, at a gross weight of 1320 pounds. If the builder foregoes Sport Pilot limits, and declares a 1450-pound gross weight, the available weight for occupants and baggage increases to 488 to 508 pounds with full fuel, making it a very practical two-person cross-country aircraft.

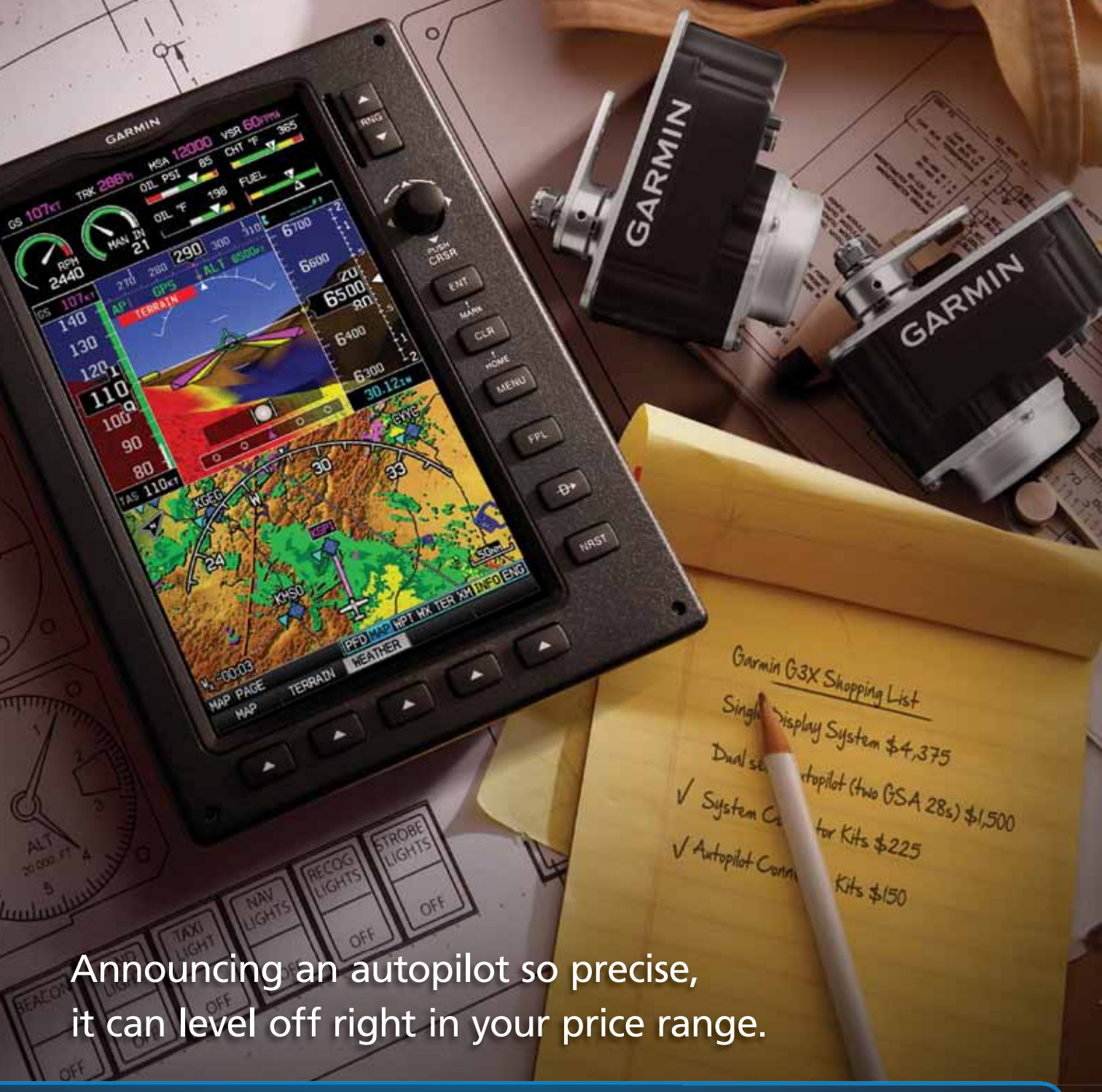
In the Air

Enough talking. Time to finally go flying! The aircraft is easily pushed out of the hangar using a hand tow bar on the nosewheel. As with all Rotax 912 engines, the prop should be turned several times to pump oil from the engine to the dry sump oil tank prior to checking the oil level. Coolant level is checked through the same door as the oil level. All other walkaround items are completely standard.

The cockpit is accessed from in front of the left wing, using the fixed step that hangs down from the forward fuselage. Put the left foot on the step, grasp the canopy sill, step up, and place the right foot on the wing walk area behind the main wingspar. Step onto the seat and into the cockpit. It's ten times easier than getting into the back seat of my RV-8. Both front and rear seats adjust fore and aft to accommodate different pilot leg lengths. Both seats have four-point harnesses (three-point harnesses were installed at the time of the flight review, but the design has since been updated to four point).

The right side hinged canopy is latched by lowering it to the sill, pushing forward to engage the securing hooks,

The aircraft looks good with or without the canopy.



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* This LVL feature requires the optional GMC 305 autopilot control panel

** Price does not include installation kit, which costs from $45-$150, depending on aircraft configuration.

G3X™ Flight Systems

The 4130 steel protection cage carries the structural loads in the cockpit area.

then locking it in place with a lever that prevents aft movement. The canopy is very high, allowing adequate headroom for pilots with very long torsos. The aircraft can be quickly converted to an open-cockpit configuration by removing the three canopy hinge bolts. The fixed windscreen provides good protection for the front seat, but the rear seat would likely be a windy place. A creative builder could possibly craft a suitable removable rear seat windscreen. SAM reports that the aircraft is approximately 10 mph slower when flown with the canopy removed.

The rear seat controls include throttle, stick, and rudder pedals. The rear seat rudder pedals are reached by putting the feet in tunnels beside the front seat. These tunnels are somewhat narrow, and those with extra wide feet may find they don't fit in the tunnels. My 4³/₈-inch wide, size-10 running shoes barely made it. SAM is investigating mods to make these tunnels wider, but that may not be possible due to the constraints of the cockpit protection cage and front seat structure.

The engine start is standard Rotax 912. Throttle idle, fuel pump on, choke on (only if the engine is cold), then turn the key to start. Warm-up is at 2500 rpm, releasing the choke as the engine warms up. The runup consists of an ignition check at 4000 rpm.

The aircraft is a joy to taxi. The nosewheel steering is controlled via the rudder pedals. A bit of brake will assist to allow very tight turns if required. There is excellent visibility from the cockpit during taxi.

The takeoff weight was close to 1320 pounds. Takeoff was accomplished with the flaps retracted, with a rotate speed of 65 mph, transitioning to a climb speed of 75 mph. The combination of nosewheel steering and aerodynamic control from the rudder made it easy to track the runway centerline. SAM has conducted takeoffs with up to a 15-mph crosswind, but it is likely that the actual aircraft crosswind capability is quite a bit higher than that. The normal climb speed is 75 mph. The long cowling blocks the visibility directly ahead in the climb, so S-turns are advised to ensure there is no traffic ahead. The observed climb performance

Advanced Ultra-Light Aeroplane (AULA)

What if I told you about simple, two-seat aircraft that comply with design standards proposed by industry, and can be flown with a pilot license that has simpler training and medical requirements than a Private Pilot License. This sounds like LSA, but this has been available since 1991 in Canada—the Advanced Ultra-Light Aeroplane category (AULA), and the Recreational Pilot Permit.

Back in the late 1980s, the ultralight community in Canada wished to obtain approval to carry passengers in their aircraft. Transport Canada was not prepared to allow carriage of passengers, as there were no design standards for ultralights; thus the regulators considered the risks to passengers to be too high. Transport Canada would be prepared to allow ultralights to carry passengers—if they met an acceptable design standard.

The movers and shakers in the Canadian ultralight community put their heads together and drafted a proposed set of simple design standards. These standards were accepted by Transport Canada in 1991 as the Design Standards for Advanced Ultra-Light Aeroplanes. The aircraft had a maximum of two seats, were propeller driven, with a maximum gross weight of 1058 pounds (later increased to 1232 pounds), and a maximum stalling speed in the landing configuration of 45 mph IAS, and 60 mph IAS or less with flaps retracted. AULAs could be sold as kits, to be assembled by the buyer, or as completed aircraft, ready to fly. In either case, the company responsible for the design must certify that the completed aircraft complies with the type design, and no modifications are allowed without the approval of the design holder.

AULA can be flown by pilots holding a Recreational Pilot Permit, which has simpler training requirements than a Private Pilot License. Medical requirements are also less stringent.

The creation of the AULA category allowed a new industry to flourish in Canada, building simple, robust, two-place aircraft with relatively low acquisition, operating, and maintenance costs. The success of the AULA concept in Canada served as one of the many sparks for the creation of the Light Sport Aircraft concept. The AULA design standards were used as one of the starting points for the ASTM LSA design standards, but the eventual LSA requirements do have many important differences to AULA.

Now we just need the FAA to follow Canada's lead with the Owner Maintenance category. The Owner Maintenance category was created to address the difficulty in maintaining older aircraft that may no longer have support from a type design holder, or a ready supply of replacement parts. In Canada, since 1996, the owner of some simple, out of production light aircraft can voluntarily move the aircraft into the Owner Maintenance category. The owner can then perform maintenance and modifications without any requirements for any signoffs by maintenance personnel or any regulatory approval of the modifications—i.e. Owner Maintenance aircraft are treated similar to amateur-built aircraft.

—K.H.

on this warmer-than-standard day was consistent with SAM's claimed climb rate of 710 feet per minute at a 1320 pound weight at sea level on a 59° F (15° C) day.

The large canopy provides excellent visibility during cruise. The prototype has large pop-out fresh air vents in the canopy. These provide adequate fresh air for a Canadian summer day, but operators in Texas may prefer to fly with the canopy removed. The observed cruise speed of 120 mph IAS at 3500 feet is respectable, especially considering that the SAM LS is quite large for an LSA. The prototype did not yet have wheelpants covering the landing gear—SAM reported from later testing that the large wheelpants increased the cruise speed less than 1 mph. Note that the airspeed system has not been calibrated, so no attempt was made to convert IAS to TAS.

The aircraft responds well to flight-control inputs, with pleasantly light aileron forces and moderately sporty roll rates. The differential Frise ailerons do a good job of minimizing adverse yaw, so little rudder input is required during turn entry and exit. The aircraft has neutral spiral stability, holding bank angle if the stick is released, assuming the fuel load is balanced between the left and right tanks. The aircraft has good directional stability and control. The dihedral effect is on the low end of the normal range; if the pilot steps on the rudder, there is some resulting roll rate, but the roll response is slow.

Pitch stability and control is excellent. The stick forces in pitch are a happy medium between tiring and twitchy. A change in speed without retrimming requires moderate stick force, showing good static longitudinal stability. There is little friction in the pitch control system, so the free return speed is very close

The Rotax 912S is mounted well ahead of the instrument panel, providing easy maintenance access. This also allows a heavier engine to be mounted further aft, keeping the empty CG in the right range.

What's in the Name?

At Oshkosh, the most-often asked non-technical question about the SAM Aircraft was, "What does the name mean?" SAM Aircraft's name has a simple explanation: Samuel Zibi, first child of Thierry Zibi, was born two years ago. At that time, Thierry changed the name of the company (from HAIM Aviation) to SAM Aircraft. The company and the first airplane design bear his name. (Photo of Thierry and Samuel in the SAM cockpit on his recent second birthday, below. Note that little Samuel already has his hand around the keys.)

— Thierry Zibi

The baggage bay is above the rudder pedals, and is accessed via a top-hinged door on the left side of the fuselage.

to the original trimmed speed, if the stick force is slowly released.

If the stick is released with the aircraft off the trimmed speed, the resulting roller coaster phugoid motion is positively damped, and the phugoid period is normal for aircraft of this speed. The electric pitch trim is controlled via a rocker switch on the stick, and the trim rate strikes the right balance between painfully slow and overly sensitive.

The SAM LS has a 15% thick NACA 23015 airfoil; the Van's RV-4 through RV-8 have a 13.5% thick version of the same airfoil. Not surprisingly, the SAM LS has very similar stall characteristics to these RVs. The stick forces build progressively as the aircraft decelerates. With the flaps up, there is strong buffet about a half mph prior to the stall, which occurred at 47 mph IAS with power at idle. The nose drops at the stall, but there is no wing drop. The wing starts flying again as soon as the stick is moved forward to reduce the angle of attack. With the flaps extended, weak stall warning buffet starts about 3 mph prior to the stall, with the stall at 42 mph. Once again, the nose drops at the stall, but there is no wing drop, and stall recovery is immediate once the pilot moves the stick forward. Stall characteristics in turns and with power on were similar. All in all, the SAM LS has excellent stall characteristics, but marginal stall warning.

Ideally, it would be better to have stall warning come earlier, but there are many thousands of RVs flying with similar poor stall warning, and they aren't falling out of the sky at an unusual rate due to lack of stall warning. For maximum safety, it is recommended that an artificial aural stall warning be installed, either with a "tongue depressor" tab on the leading edge driving a warning buzzer, or using one of the many available angle of attack systems.

No spins were flown during this evaluation, as SAM had not yet conducted spin testing. SAM did initial spin testing following the KITPLANES® flight evaluation, and they report that they were unable to force the aircraft to enter a spin at forward CG, either with conventional spin entry attempts or in simulated abused final turn stalls. SAM had not yet conducted aft-CG spin tests when this flight review was written.

The aircraft gains speed quickly during descent, so care must be taken to avoid exceeding the 155 mph VNE. The large canopy and high seating position provide excellent visibility during descent, approach, and landing. Once the aircraft is leveled off, it is easily slowed to the 90 mph max speed for flap extension. Final approach is flown at 60 to 70 mph, depending on aircraft weight, surface wind conditions, and runway length available. Airspeed and rate of descent are easily controlled with stick and power. The long-stroke landing gear absorbed my less-than-perfect first attempt at a smooth touchdown. The second landing was better. The SAM LS is a pleasant aircaft in the approach and landing phase.

Conclusions

The SAM LS has many interesting features: 4130 steel tube protection cage surrounding the cockpits, removable canopy, robust landing gear with nosewheel steering, dual controls, roomy cowling, structure stressed for 1450-pound gross weight, etc. But, these nice features come with the cost of increased structural weight. The aircraft has an empty weight of 810 to 830 pounds, depending on how the aircraft is equipped. This is far from the highest empty weight of aircraft aimed at the Sport Pilot market (one of the popular Cub clone LSAs has an empty weight of 894 pounds, and several other popular LSAs have empty weights of 820 pounds or greater), but it is higher than ideal for this market. This empty weight allows a useful load of 490 to 510 pounds at a Light-Sport-compatible 1320 pound gross weight. Full fuel (22 gallons) is 132 pounds, leaving 358 to 378 pounds for occupants and baggage. If you don't need to comply with the Sport Pilot weight limit, the design gross weight of 1450 pounds would allow a useful load of 620 to 640 pounds, or 488 to 508 pounds, plus full fuel. SAM also markets the aircraft in the Canadian AULA category, but that limits the gross weight to 1232 pounds, which limits the useful load to 402 to 422 pounds.

If you are looking for a fun-to-fly amateur-built or LSA aircraft with classical lines, but modern design and materials, the SAM LS deserves a close look. SAM Aircraft has announced a 20% discount, available until the end of winter 2014, so the timing is right if this is the right aircraft for your mission. ✚

KEVIN HORTON

Kevin Horton learned to fly in a J-3 Cub way too many years ago then flew S-2 Trackers in the Canadian military. He spent a year at test pilot school in France and has worked full time as a test pilot for over 25 years. In his spare time he flies the RV-8 he built.

2014 Plansbuilt Buyer's Guide

Not everyone starts with a kit!

BY PAUL DYE

Last month in KITPLANES®, we took our annual look at the airplane kits currently available on the market. What many people don't realize is that, even though our name is KITPLANES®, we are really here to serve the entire homebuilt market. The roots of homebuilding go back many years before the first successful kits came out—first with scratch built airplanes, then moving on to the plans industry. For many years, those dreaming of building an airplane started with the pages in the front of the Aircraft Spruce and Specialty catalog—the place where you could buy plans and "materials kits"—carefully chosen raw materials to help a person get started on an airframe. Note that "airframe" didn't encompass anything but the basic structure; the builder still needed to determine for themselves what was needed for systems, electrical, firewall forward, and all of the hundreds and thousands of little pieces that make a structure into an airplane.

To the surprise of many, plans building is still popular because many of the aircraft designed up through the 1980s—and into the '90s—are not available as kits. This includes most of the composite canard designs by Burt Rutan and other designers from that era. Moldless fiberglass construction lends itself to materials kits and plans building because the builder starts with nothing but blocks of foam and spools of cloth. Kits for composite aircraft became popular once the fuselage and wings were being produced using molds—then the builder would receive large chunks that already looked like airframe components, rather than packing materials.

An interesting category of Experimental aircraft that has grown somewhat organically out of the plans and kit industry are those types that can be built either way. Many of the aircraft listed in our online directory can be built from complete kits—or you can purchase the plans and start from scratch—or purchase as many piece-parts as you wish from the kit manufacturer. Zenith aircraft are a good example of this slice of the industry. For someone who likes to find bargains and has access to the necessary tools (and time) to fabricate components from raw stock, this is a fun and rewarding way to build. This route also allows a builder to change their mind in the middle of the project if they wish to speed things up and get to the finish line faster.

Why Plans?

While kit-building dominates the homebuilt market today, there are still many people who prefer to build from plans for a variety of reasons. It is hard to rate which of these reasons is most—or even more—important, because everyone's motivations are different, and choosing an aircraft to build is a very personal decision. But we can list a few of the considerations that drive someone to the road less traveled:

Availability—Many people simply fall in love with a particular aircraft design, and their reason for building is to have "one of those." Whether it is a classic biplane, such as a Starduster or Acrosport, or the potential builder just simply has to have a sexy-looking Long-EZ, it makes no difference to them what route they have to take to get one. And if starting with a plans set is the only way to go, so be it. There is no doubt that builders are dreamers, and many dreams

began early. If your childhood room had posters of Pietenpols or Hyperbipes in your formative years—and you still have those posters carefully stored away or on your office wall today—you might have no choice but to go with plans.

Challenge—For many, they simply haven't built an airplane unless they truly fabricated all of the components. We hear good-natured ribbing at airshows and fly-ins about kit-builders simply being "assemblers," while the guys who started from scratch are "builders." The truth, of course, is that unless you planted the seedling for the spruce tree, watered it, watched it grow—then cut it down and milled the wood for your spar—you still jumped into the process at some point along the continuum. Starting with raw aluminum, fiberglass, or wood stock and a set of plans is generally considered good enough to put you in the "I built it without a kit" crowd—and that is quite a challenge.

A Unique Design—A few builders have had their own design in mind for many years, but going from a blank sheet of paper to a finished airplane is more daunting than most can imagine. Oftentimes, a builder will see an airplane design that is close to what they want, but will require a great deal of modification in key areas. One example is when they want to change the size of the cockpit to accommodate themselves (either making it bigger or smaller), or in changing some other aspect of the airframe that will significantly alter most of the major components. In this case, starting with a kit would be wasteful; but starting with a set of plans and stretching a little here, reshaping a bulkhead there—that makes sense.

Fiscal Realities—Many people want to build an airplane today for the same reasons that many homebuilders got started in the 1950s—they want an airplane, but simply don't have a lot of money. They can't afford to purchase a kit, or even the sub kits for an airplane, but they can afford a few hundred dollars now and again for raw materials. They may not have money, but they have the time, and sweat equity (along with a nice set of plans) is a great way to

Photos: KITPLANES® Staff, Richard VanderMeulen, and courtesy the manufacturers.

Planning to Build from Plans?

While the majority of Experimental/Amateur-Built aircraft completions these days are coming from kits, there is still a great deal of interest in plans building. Plansbuilt aircraft can take longer to build—and longer to get started. Many potential builders have a set of plans that they have been dreaming about for many years, so looking at the rate of plans sales today doesn't really reflect the number of plans for a given model that are sitting on workbenches or desks, waiting to be started. The numbers also don't reflect the number of aircraft actually being built. But they can give us an idea of what folks are dreaming about at the current time. One of the largest sellers of plans is Aircraft Spruce and Specialty, and we asked them what has been selling from their catalog this year and last. The results give some indication of what's popular.

Plans Sold	Year to Date	Last Year	Total
W10 Tailwind Plans	31	32	63
COZY Mark IV Plans	19	30	49
Starduster Too SA300	6	6	12
Acroduster Too SA750	5	7	12
Wittman V-Witt Racer	4	7	11
Starlet SA500	4	5	9
One Design Plans	2	4	6
Buddy Great Lakes	2	3	5
Baby Great Lakes	1	3	4
Starduster One SA100	2	1	3
Super Baby Great Lakes	0	3	3
Christavia MK-1 Plans	0	2	2
Christavia MK-4	1	1	2
V-STAR SA900	0	1	1
Christavia MK-2 Plans	0	0	0
Super Starduster SA101	0	0	0
Acrolite 1B Plans	0	0	0

The editors at KITPLANES® are happy to see that the top three represent quite a bit of diversity—a classic, a canard, and a biplane. Frankly, that is what building airplanes is all about—building what you want, building your dream.

This Baby Great Lakes appeared in the November 2012 issue of KITPLANES®.

Top Sellers

1 W10 Tailwind

"Introduced at the first EAA fly-in 1953, Tailwind was designed and built by legendary designer and air racer Steve Wittman. This high-performance homebuilt is constructed with a steel tubing fuselage, wood wings, and fabric covering. It offers exceptional cruising speeds and is economical to operate and maintain."

– Aircraft Spruce and Specialty

Specifications:

Seats	2
Design HP	145
Max Speed	200 mph
Stall Speed	45 mph
Range	690 sm

2 Cozy Mark IV

"The Cozy MK IV is a high-performance, four-seat canard aircraft which is comfortable, efficient, and economical to build. It has a range of about 1,000 miles and a top speed of 200 mph. When constructed according to plans and operated within the approved C.G. range, the canard configuration makes it highly resistant to stalls or loss of position control. The MK IV features full dual control and two-axis trim. The composite construction is very strong, resistant to corrosion and fatigue, and offers better protection to the occupants than other types of construction."

– Aircraft Spruce and Specialty

Specifications:

Seats	4
Design HP	180
Max Speed	200 mph
Stall Speed	69 mph
Range	980 sm

get into the air. It can take a lot longer, but for many, that doesn't matter. If you have airplane parts in your workshop, you're a builder.

Sources

I bet that most builders come to the plansbuilt world with an airplane already in mind—something that they saw at a fly-in, in a calendar shot, or that they have been thinking about for years. You can find a lot of information and pictures in the front of the Aircraft Spruce catalog, and many dreams have been started with that big book—but builders come to their design in many different ways.

Wander the ramp at your local field or visit an EAA chapter close to you. In fact, one great way to see interesting airplane ideas and meet new builders is to visit EAA chapters far away—when on an overnight business trip or a vacation for instance. Take time to find the airplane that is right for you; the truth is, the build will become a huge part of your life.

Finding the plans for the airplane of your dreams is as simple as logging on to *www.kitplanes.com* and checking out the Online Buyer's Guide. You can search for airplanes that fit your specific design parameters, or simply look the design up by name or manufacturer. You can compare models based on specifications, hours it takes to build, materials used—just about any parameters you care to use. And once you have found that plane, the listings will tell you where to go for plans: the name of the company or contact, as well as phone numbers and web site information.

The Reward

Building an airplane that comes as a kit is a remarkable achievement in anybody's book—and building one from plans (or from scratch) can be even more remarkable. Whether that aircraft is simple or complex, knowing that you marked all of the dimensions, drilled every hole, and formed every shape is something that you can never lose. While our title says "KITPLANES®," we applaud and support the entire homebuilding community. The plans builders might not appear in these pages quite as often, but that is only because they are hidden away in workshops all around the world, toiling away at projects that will be exactly what they want—and satisfy that dream of homebuilt, affordable flight.

3 Starduster Too SA300

Specifications:

Seats	2
Design HP	180
Max Speed	180 mph
Stall Speed	56 mph
Range	560 sm

"This is the best-known biplane across the country. It is a two-place machine, large enough for two and baggage, fast enough for cross country if you want to really enjoy life, and without question the prettiest biplane ever built. It is rated +/- 6 G, so most aerobatics can be performed. Powered with engines from 125 to 375 hp, the 180 and 200 HP Lycoming are most popular. First flown in the 1960s, there are more than 1,000 flying. This is what flying was meant to be."

– Aircraft Spruce and Specialty

2014 Plansbuilt Aircraft

Here is an overview of available plansbuilt (only) aircraft for 2014. You'll find full details about each model, and have the ability to make side-by-side comparisons, at *www.kitplanes.com/aircraftdirectory.* Prices shown are estimated completed prices.

Manufacturer/Web Site	Model	Seats	Cruise Speed	Max Speed	Stall Speed	LSA Legal	Price
Acrolite Aircraft *www.acrolite.org*	Acrolite 1B	1	110	130	45	✔	$10-25k
	Acrolite 1T	1	90	110	44	✔	$8-20k
	Acrolite 2M	2	105	125	43	✔	$12-30k
Adams Aeronautics Company, Inc. *www.adamsaero.com*	CA-2 (formerly Hummel)	1	63	80	26	✔	$4-8k
	T-100D Mariah	1	63	80	27	✔	$4-8k
Aero-Systems *www.ibeatyouthere.com/culver/*	Cadet Model STF	2	130	145	50		$35-48k
Aircraft Spruce & Specialty *www.aircraftspruce.com*	Acroduster Too SA-750	2	155	185	55		
	Acrolite 1B	2	110	130	43	✔	$7k
	Baby Great Lakes	1	118	135	55	✔	
	Buddy Baby Lakes	2	135	135	55		
	Christavia MK 1	2	105	119	40		$8-14k
	Cozy Mark IV	4	190	220	69		
	One Design DR 107	1	160	184	60		
	Starduster One SA-100	1	132	147	50	✔	
	Starduster Starlet SA-500	1	105	150	55		
	Starduster Too SA-300	2	130	180	56		
	Starduster V-Star SA-900	1	75	90	35	✔	
	Super Baby Great Lakes	1	135	155	55		
	Super Starduster SA-101	1	170	200	55		
	Wittman V-Witt Racer	1	150	180	48		
	Wittman W10 Tailwind	2	180	200	45		$12k and up
Andrew Budek-Schmeisser	Jungster 1 Biplane	1	110	150	55		$12-25k
	Jungster 2	1	160	200	50	✔	$10-20k
Aviat Aircraft, Inc. *www.aviataircraft.com*	Pitts S-1-11B (Super Stinker)	1	187	205	54		$100k and up
BHP And Sons Air Camper Aircraft L.L.C. *community.pressenter.net/~apietenp/*	Pietenpol Air Camper	2	80	100	40	✔	$6-16k
	Sky Scout	1	55	70	35	✔	$4-16k
Blanton, D. L.	Sport Racer	2	175	200	62		$25-35k
	V6 STOL	4	120	135	48		$25-35k
	Wichawk	3	127	140	56		$20-40k
Bowers (Bowers, David R.) *www.bowersflybaby.com*	Bowers Fly Baby	1	87	110	45	✔	$10-12k
Clutton, Eric	Fred	1	75	80	40	✔	$5-12k
C-N-C Aviation	Supercat	1	80	100	32	✔	$7-12k
CSN	Corby Starlet CJ-1	1	130	160	35	✔	$15-27k
Danieli, Tiziano *www.piumaproject.com*	Piuma Evolution	1	62	72	35	✔	$8-12k
	Piuma Motorglider	1	50	59	30	✔	$8-12k
	Piuma Tourer	1	84	93	39	✔	$8-12k
	Piuma Twin Evolution	2	92	103	44	✔	$10-14k

Information based on manufacturer-supplied data. All speeds are in mph.

For a side-by-side comparison of models, visit *www.kitplanes.com/aircraftdirectory.*


Falconar Cubmajor

Great Plains Sonerai II Original


Littner Jewel

Manufacturer/Web Site	Model	Seats	Cruise Speed	Max Speed	Stall Speed	LSA Legal	Price
DCS, Inc. *www.teenietwo.com*	Mini Coupe	1	100	110	48	✔	$8-20k
	Teenie Two	1	110	120	48	✔	$7-20k
Design Resources	J. D. Special	1	140	170	38		$11-40k
Dyke Aircraft	Dyke Delta JD II	4	180	210	60		$9-30k
Early Bird Aircraft Co.	Jenny, 2/3rd scale	2	60	70	35	✔	$8-13k
Eklund Engineering, Inc. *www.thorpt18.com*	Thorp T-18	2	200	205	59		$20-45k
Falconar Avia Inc. *www.falconaravia.com*	Cubmajor	2	100	120	40	✔	$10-33k
	Falconar F10A	1	120	140	35	✔	$9-30k
	Falconar F11E	2	100		42	✔	$10-37k
	Fauvel AV36/361/AV362	1	60	137	30	✔	$9-20k
	HM 290/293	1	90		28	✔	$5-26k
	HM 360	1	95	120	28	✔	$7-34k
	HM 380	2	95	120	28	✔	$7-34k
Flight Addictions LLC (Alarie, Russell) *www.daisymae-biplane.com/*	Daisy Mae	2	80	100	40	✔	$17-30k
Great Plains Aircraft Supply Co., Inc. *www.gpasc.com*	Easy Eagle I Bi-Plane	1	100	110	45	✔	$8-12k
	Sonerai I	1	150	200	45		$10-20k
	Sonerai II Original, LT, L	2	140	200	45	✔	$10-20k
	Sonerai II Stretch	2	140	200	50		$10-20k
Green Sky Adventures, Inc. *www.greenskyadventures.com*	Zippy Sport	1	110	120	45	✔	$10-25k
Hatz Biplane Association *www.hatzbiplane.com*	Hatz CB-1	2	90	105	38		$12-80k
	Kelly-D	2	90	105	40		$12-80k
Hevle Aviation LLC *www.hevleaviation.com*	Hevle Classic	2	105	135	45	✔	$19-40k
Littner, S.	C.P. 1320-Saphire	4	167	200	53		
	C.P. 150 Onyx	1	50	62	22	✔	
	C.P. 328 Super Emeraude	2	142	150	56		
	C.P. 60 Super Diamant	4	155	160	55		
	C.P. 750 Beryl	2	160	185	56		
	C.P. 80 Zephyr	1	175	200	50		
	C.P. 90 Pinocchio	1	140	150	45		
	Champion V	2	143	155	47		
	Jewel	2	177	186	40		
	Junior VI	2	100	125	38	✔	
	Whisky IV	2	130	183	37		
Luceair *www.luceair.com*	Wittman Buttercup	2	130	155	45	✔	$13-23k
Mann, Roger *www.ragwing.net*	RW1 Ultra-Piet Pete	1	55	85	28	✔	$5-10k
	RW11 Rag-A-Bond	2	78	105	38	✔	$8-25k
	RW16 Aerial	1	60	90	28	✔	$5-10k

Information based on manufacturer-supplied data. All speeds are in mph.

For a side-by-side comparison of models, visit *www.kitplanes.com/aircraftdirectory.*


Roger Mann RW8


Meyer's Little Toot


Mirage Celebrity

Manufacturer/Web Site	Model	Seats	Cruise Speed	Max Speed	Stall Speed	LSA Legal	Price
Mann, Roger *www.ragwing.net*	RW19 Stork	2	75	105	22	✔	$15-30k
	RW2 Special I	1	70	125	30	✔	$8-18k
	RW20 Stork Side-By-Side	2	75	105	22	✔	$10-25k
	RW22 Tiger Moth	2	80	110	35	✔	$10-25k
	RW26 Special II	2	85	135	38	✔	$10-20k
	RW4 Midwing Sport	1	70	95	28	✔	$5-10k
	RW5 Heath Replica	1	60	85	28	✔	$5-10k
	RW6 RagWing Parasol	1	66	85	28	✔	$5-10k
	RW7 Duster	1	65	95	28	✔	$5-10k
	RW8 RagWing Pt2S	2	75	95	36	✔	$10-25k
	RW9 Motor Bipe	1	60	95	36	✔	$5-10k
Meyer Aircraft *www.littletootbiplane.com*	Meyer's Little Toot	1	125	138	51	✔	$20-45k
Mirage Aircraft, Inc. *www.mirage-aircraft.com*	Celerity	2	205	225	60		$27-59k
	Marathon	2	190	205	60		$23-42k
nV Aerospace (was Rand-Robinson Engineering, Inc.) *www.nvaero.com*	KR-1	1	180	200	52		$9-15k

Information based on manufacturer-supplied data. All speeds are in mph.

For a side-by-side comparison of models, visit *www.kitplanes.com/aircraftdirectory*.

Editor's Whim: RLU-1 Breezy

Like a kid in a candy store, choosing a single aircraft design out of all the ones available to be my "favorite" or "best" is an impossible task. So many airplanes, so little time to fly and build; I could go for something fast, something long ranged, something sporty, or something to haul a moose out of the backcountry. Who can resist a biplane? Or… how about a Super Cub clone? I think that today, I'll settle for a very unique aircraft, one that is almost synonymous with homebuilding (or in the minds of the public, those crackpots who will fly anything!)—the Breezy!

I think the Breezy epitomizes the spirit of homebuilding: taking whatever wings and engine you might have and create a flying machine with absolutely no frills. It is freedom in the air—and freedom in the design process—that can't be beat. I can't say that a Breezy is high on my list to actually build, but I must say that when I think of "homebuilt," the Breezy invariably comes to mind.

—Paul Dye

Specifications:

Seats	3
Design HP	90
Max Speed	105 mph
Stall Speed	33 mph
Range	280 sm

From the Aircraft Spruce Catalog:

"Designed and constructed by Charles Roloff, Carl Unger, and Bob Liposky, the Breezy was first introduced in 1965 and hailed as one of the most distinctive and unusual homebuilt designs to ever attend an EAA Fly-in. Though there have been a lot other designs, particularly homebuilts, that embody the open cockpit which trademarks a Breezy, nothing can surpass it for the view and fresh-air feeling. The original Breezy was designed and built to accept a set of PA-12 wings. For that reason, there are no wing drawings with the plans. It is possible to substitute PA-14, PA-18, or J-3, J-4, or J-5 wings. It's also possible to order wing kits that replicate a J-3 wing. Power for the prototype, which now hangs in the EAA Aviation Museum in Oshkosh, WI, is a Continental C-90. The Breezy will carry a pilot and two passengers."


Pazmany PL-9 Stork

Bearhawk Patrol


Coot Amphibian

Manufacturer/Web Site	Model	Seats	Cruise Speed	Max Speed	Stall Speed	LSA Legal	Price
Pazmany Aircraft Corp. *www.pazmany.com*	Pazmany PL-1	2	115	120	54		$28-40k
	Pazmany PL-2	2	119	138	52		$29-45k
	Pazmany PL-4A	1	97	120	39	✔	$18-25k
	Pazmany PL-9 Stork	2	104	116	33		$28-45k
Preceptor Aircraft Company (Corp.) *www.preceptoraircraft.com*	N-3 Pup	1	60	63	27	✔	$17-19k
	Stinger	1	80	90	35	✔	$22-26k
	STOL King	2	90	115	15	✔	$33-45k
	Super Pup	1	80	90	35	✔	$22-30k
	Ultra Pup	2	80	105	35	✔	$22-30k
Pro-Composites Inc. *www.pro-composites.com*	Vision EX	2	157	207	54		$30-40k
R & B Aircraft *www.bearhawkaircraft.com*	Bearhawk (plans)	4	130	142	42		$24-40k
	Bearhawk LSA	2	125	140	30	✔	$60-75k
	Bearhawk Patrol	2	140	156	35		$22-40k
Richard Steeves *www.coot-builders.com*	Coot Amphibian	2	110	140	50		$25-50k
Sky Classic Aircraft *www.skyclassic.net*	Smith Miniplane 2000	1	125	135	60		$7-25k
Spencer Aircar *www.geocities.com/Paris/Concorde/7563*	Spencer Air Car	4	140	155	53		
St. Croix Aircraft *www.stcroix.50webs.com*	Pietenpol Aerial	2	85	110	40	✔	
	Pietenpol Air Camper	2	75	90	40	✔	
	Sopwith Triplane (1916)	1	100	120	40		

Information based on manufacturer-supplied data. All speeds are in mph.

For a side-by-side comparison of models, visit *www.kitplanes.com/aircraftdirectory.*

Editor's Whim: Osprey Aircraft GP-4

If I were to build from plans, it would have to be something unusual. I'd like the end result to be an aircraft you're not likely to see at a typical fly-in.

Because plansbuilt projects take so long to complete, I'd like to gain back some of that time by building an airplane that's fast. And since I'm going to be spending so much time in the shop, I probably won't have time to get a tailwheel endorsement, so I need to build something with tricycle gear.

Last, but not least, I'd like to learn new skills. That means I need to choose a project that's made from a material I don't have much experience with—most likely wood.

Let's see…fast, unusual, trigear, wood; it sounds like I'm building an Osprey Aircraft GP-4!

Designed by George Pereira, the retractable-gear GP-4 prototype was finished in April 1984 and was recognized by the EAA as an Outstanding New Design. Plans for the GP-4 consist of 57 large sheets, with full-scale drawings of many key parts. The drawings can be used as patterns for each component. Also included is a 55-page builder's manual with photos and instructions.

Most of the structure is made from wood, with a fiberglass cowling and a few metal parts. If welding and fiberglass work is a problem, these parts can be bought from an approved vendor.

There's no question the GP-4 is an enormous project; to date only about 40 have been completed and flown. To be honest, I don't know where I'd find the time to complete such a project. But for builders who do, the reward will be a sleek, unusual airplane that performs as good as it looks.

—Mark Schrimmer

Specifications:

Seats	2
Design HP	200
Max Speed	255 mph
Stall Speed	62 mph
Range	1100 sm


Steen Skybolt


Vintage J3-JR


Zenith Zodiac CH601UL

Manufacturer/Web Site	Model	Seats	Cruise Speed	Max Speed	Stall Speed	LSA Legal	Price
Steen Aero Lab, Inc. *www.steenaero.com*	Firebolt	2	170	214	61		$40-105k
	Great Lakes Sport Trainer	2	125	138	40		$50-120k
	Knight Twister	2	145	180	56		$25-90k
	Pitts S1-C	1	154	200	64		$25-75k
	Skybolt	2	170	210	68		$35-100k
Stewart Aircraft Co. *www.stewartaircraft.com*	FooFighter	1	115	120	48	✔	
	Headwind B	1	85	90	40	✔	$10-35k
Taylor, T. *www.taylortitch.co.uk*	Taylor Monoplane	1	100	115	40	✔	$9-11k
	Taylor Titch	1	160	200	52		$11-15k
Thatcher Aircraft Inc. *www.thatchercx4.com*	Thatcher CX4	1	125	130	40	✔	$12-18k
Turner Aircraft, Inc. *www.turnert-40airplanes.com*	T-40	1	145	170	45		$8-20k
	T-40A	2	147	160	56		$12-30k
	T-40A Super	2	155	175	62		$20-35k
Unger, Carl H	Breezy R.L.U.-1	3	80	105	33		$8-12k
Viking Aircraft	Cygnet	2	100	110	48	✔	$14-16k
Vintage Ultra and Lightplane Assoc. *www.vula.org*	Beta Bird	1	80	80	45	✔	$2-5k
	Gypsy	1	45	55	22	✔	$2-5k
	J3-JR	1	45	55	25	✔	$2-4k
	MW-7	1	55	85	35	✔	$2-5k
	Skypup	1	50	69	26	✔	
	Whing Ding	1	35	45	24	✔	$2-5k
	Woodhopper	1	30	40	18	✔	$2-5k
VSR *www.snoshoo.com*	SR-1 Snoshoo	1	200	260	65		$15-30k
WAR Aircraft Replicas *www.waraircraftreplicas.com*	A6M2-Zero	1	135	155	55		$18-24k
	F-4U Corsair	1	135	155	55		$18-28k
	F8F Bearcat	1	135	155	55		$17-26k
	Focke Wolf 190	1	135	155	55		$16-26k
	Hawker Sea Fury	1	135	155	55		$16-26k
	Hurricane	1	135	155	55		$17-26k
	Messerschmidt BF-109	1	135	155	55		$18-24k
	P-47 Thunderbolt	1	135	145	55		$14-26k
	P-51 Mustang	1	135	155	55		$17-26k
Williams, Lynn *www.flitzerbiplane.com*	Flitzer Z-21	1	93	105	42	✔	$10-25k
York Enterprises *www.yorkaircraft.com*	Laser Z-200	1	165	180	64		$30-50k
	Laser Z-2300	2	195	250	60		$30-50k
Zenith Aircraft Co. *www.zenithair.com*	STOL CH 701 Amphib	2	74	105	32	✔	$18-60k
	Zodiac CH 601 HD	2	115	135	44	✔	$18-46k
	Zodiac CH 601 UL	2	115	135	44	✔	$18-45k

Information based on manufacturer-supplied data. All speeds are in mph.

For a side-by-side comparison of models, visit *www.kitplanes.com/aircraftdirectory.*

Trike to Dragger

Making the switch.

BY DAVE PRIZIO

The GlaStar with tricycle gear just before the switch.

Everyone says you have to fly a taildragger to be a *real* pilot. Succumbing to such nonsense, my airplane building buddy, Ed Zaleski, and I decided to convert our tricycle gear GlaStar into a taildragger. We could then become *real pilots* and chart out new adventures in flying to places where trike pilots feared to go. Besides that, we both like to work on airplanes. Being somewhat gullible and never ones to back down from such a challenge, we decided to go for it.

Why Switch?

We had flown GlaStar N634DP in the tricycle configuration for about 2½ years, logging some 485 hours. We both felt very comfortable in the airplane and had all the little bugs worked out. So why would we want to go and change the gear around and make it hard on ourselves? Actually, I'm not so sure Ed wanted to change anything. But I had these ideas of flying in Alaska and landing on gravel bars and remote dirt strips, plus I have a not-very-well-kept secret desire to get a Stearman someday. To pursue both of these dreams, getting a taildragger made a lot of sense. I could build tailwheel hours for the day when I am ready to get that old biplane, and I could really plan a trip to some remote and rugged places.

I thought the switch would be fairly easy. I thought we could do it all over the long Thanksgiving weekend. Well, it wasn't too hard, but it was harder than I thought. And it did get mostly done over the long weekend, but not quite.

Shopping for Parts

I thought we could save some money by buying some of the parts separately, but that didn't work out. The factory has a complete package for making the switch with all the parts you need, or at least pretty much all the parts you need. I tried to price the major items out separately to save money, but couldn't beat the factory price for the whole package. I could have saved by going with used stuff, but I was too impatient to look around for it. I also wanted to go with new gear legs, which we had to get from Glasair Aviation, because I was worried about the heat treatment of the ones I had. (There having been some questions about the heat treatment done under the old Stoddard Hamilton regime.) After shopping around, we ordered everything from Glasair except the tires.

Getting Started

The first thing we did was remove the horizontal stabilizer, elevator, and the shear plates underneath. This gave us

access to bulkhead D, where we needed to install the tailwheel spring bracket. It also gave us access to the bottom of the rudder assembly, where we would install the cables for the tailwheel steering. The installation of the added fiberglass and the tailwheel spring bolt bracket would have gone very smoothly except that some dummy with the initials DP attached the first bracket to bulkhead C by mistake. Can you imagine someone being so inept? Anyway, the rest of the tail work went pretty well, once we sorted that out.

The book tells you to eyeball the holes for the steering cables, but a tip from another GlaStar builder gave us a better idea, which we shamelessly stole for ourselves. To get the exact position for the holes in the fuselage and in bulkhead D for the cables, I made a little device with a cheap laser pointer and a piece of 3/8-inch fuel line I had left over. I bent it so one end would rest on the rudder arm attachment point and the other end, with the laser pointer tie-wrapped to it, was tweaked so that the end of the pointer was right next to the tailwheel attachment point. The laser beam would then point to the exact spot on the fuselage for the cable hole. Then, after that hole was drilled, the light would shine through to bulkhead D where the other hole could be located and drilled. It really worked well and was so easy to do.

Ed Zaleski drills through the new brake flange and gear leg using the drill press. This was much easier and more accurate than drilling the holes in place on the airplane.

Look Ma—New Legs!

The next challenge was to jack the plane up somehow. What we decided to do was leave the tricycle gear in place and just lift the nose up enough to allow the tailwheel gear legs to be installed. For safety I drilled an anchor into the hangar floor and strapped the back end of the airplane down. This way I wasn't just relying on the blocks under the nosewheel. The tailwheel gear sockets (installed when the airplane was built) were a little rusty and rough, so we used an automotive brake cylinder hone to clear them up, being very careful not to remove too much material. The gear legs went in with only a modest amount of cussing after that. We drilled the top bolts in place since we were only going through the hollow ends of the legs. With a slow speed on the drill and good cobalt bits, this went fairly quickly.

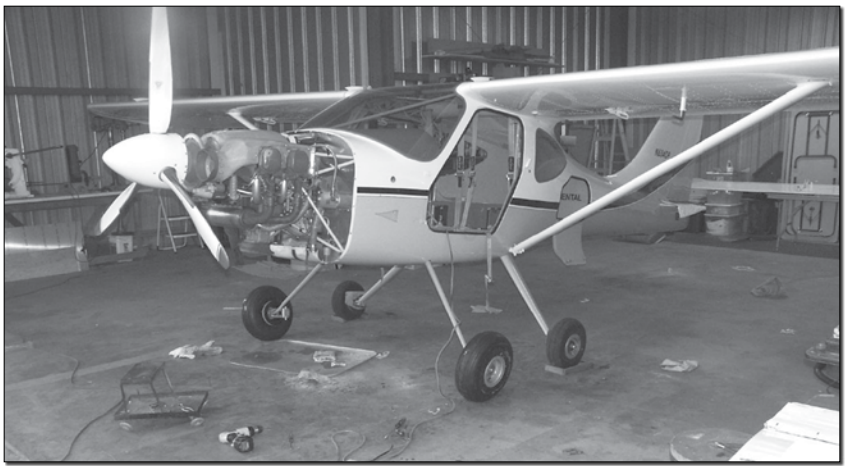
To install the 6.00x6 brake flanges we needed to drill two holes through the solid part of each gear leg. For this we started the first hole in each leg and then took the leg out and moved to the drill press. This proved to be a much better plan than drilling them in place. Assembling the wheels and brakes was very straightforward, except that we had to rob a couple of spacers from our old tricycle wheels that were not in the new kit.

After the mains were installed, we removed the old nosewheel and strut and patched up the hole in the firewall.

(Left) Ed Zaleski holds our homemade laser hole locator next to the fuselage. A bent aluminum tube and an inexpensive laser pointer made it easy to precisely locate holes for the tailwheel steering cables. (Right) Ed uses the laser hole locator to set up the steering for the tailwheel.

Photos: Dave Prizio and Nick Reid

Unfortunately the kit did not cover this item, so I had to buy a 12″x 36″ piece of stainless steel to get the 3″x 3″ patch that I needed. I also ended up making a new cowl flap, since the other one had a big slot in it for the nosewheel strut, which was no longer needed. Arguably I could have left it as is, but it would have looked kind of odd. New brake lines and reinstallation of the horizontal stabilizer wrapped things up.



It made for an odd sight to have both sets of gear hanging under the airplane. Such a sight attracted more than a few amusing—and occasionally rude—comments.

Can Mortals Fly it?

With the gear now installed, we were both anxious to go flying and see if everything worked. We tracked down our local tailwheel instructor and taxied out to try our hand at this taildragger stuff. I made five trips around the pattern just practicing 3-point landings. The taildragger GlaStar was fairly easy to handle and made me look like I knew what I was doing. The biggest problem is to just get it in my head that I really have to fly the plane until it is stopped. The tricycle airplane is so stable after landing that it can let you develop some bad habits. The taildragger is not hard to handle, but you do have to pay attention all the way back to the hangar.

I jumped out and handed the controls to Ed who had no tailwheel endorsement yet and only about an hour of total tailwheel time. He came back saying, "It sure is different!" It didn't take him too long before he had his tailwheel endorsement and was fairly comfortable with the new gear configuration.

Reviewing the Job

So how much work was it? Glasair says you can switch the gear over in an hour or two. Is that really true? Well, here's the straight story. We spent about 50 man-hours doing the work, although that was not all diligent, focused effort, and some of that was wasted with my screw-up. Now that we have done it once, I am sure we could do it in a fair bit less time, but it is clearly not a one weekend project, let alone an hour or two. Switching the gear in an hour or two means that, *after* you have already done the complete installation and have all the parts fabricated and ready to go, you could, if you had a well-equipped shop with a lift, switch the gear over fairly quickly. It is definitely not true the first time you do it.

The kit was fairly complete and fairly priced. I know because I priced out the parts from alternate sources. I couldn't beat Glasair's price without going to used stuff. At current prices the cost of the conversion, complete with new gear legs, is about $5,000. If you can save your old gear legs and reuse them, that will save about $1,500. Of course, you need to add shipping to that. On the GlaStar the tricycle mains were 5.00x5s. Switching to 6.00x6 wheels meant we had to relocate the brake flanges and drill an extra set of holes. Because of that, it was much easier to get new gear legs. If we did not change the wheel size, saving the old gear legs would have been much more feasible.

There were a few things missing from the kit. The aforementioned firewall patch is an obvious oversight. A small square of stainless steel sheet would cost very little and save a lot of trouble. It is absolutely required when going from trike to taildragger because the tricycle nosewheel strut penetrates the firewall.

The tricycle gear legs were left in place when we installed the conventional gear legs to make it easier and safer to stabilize the airplane.

The outer wheel spacers were not included, either by accident or design. I'm not sure which, but I just used the ones I had from before. The original kit came with wheel covers, but the conversion kit did not. For us this is no big deal with Aircraft Spruce right around the corner, but it would be nice to include them or at least offer them just to save time.

All in all, the kit had all the big stuff, was of good quality, and was fairly priced. The instructions were just as we would have expected, which is to say, fairly good. There is nothing we couldn't figure out from the information provided. Now all we have to do is figure out how to fly the thing without breaking anything expensive.

Paperwork and Insurance

I asked the local FSDO if they wanted to see any paperwork from me after the conversion, and they said no, which surprised me, since I was sure it constituted a major modification as per my operating limitations. They just wanted me to update the weight and balance and make a logbook entry. Neither of these need to be submitted to the FAA.

The last item is insurance. The insurance company definitely wants to know about your gear change and, of course, adjust your premium accordingly. At the time, I had about 340 hours in GlaStars but only four in GlaStar taildraggers. I had a tailwheel endorsement and about 20 hours total tailwheel time. Ed has about 150 hours in GlaStars and virtually no tailwheel time. To cover both of us in the conventionally geared GlaStar cost about $500 extra per year, with the expectation that the premium would drop as we both got more tailwheel time; this with an insured hull value of $110,000.

It wasn't too long after we made the gear conversion that we decided to build a Sportsman, so most of the great adventures we had planned were put on the back burner again. I did get as far as northern British Columbia with the taildragger 'Star, but that's another story. Did it make us *real* pilots? Well, I guess the jury is still out on that one. ✢

Electrical System Design

Getting a good start.

BY MARC AUSMAN

In the homebuilding world, we've found that some people like rivets, some people like engines, and some people like electrical systems. I'm one of the latter. But there are many people that know metal and find the wiring side of things quite daunting, especially these days, as homebuilt aircraft can be equipped with more and more electrical equipment. For example, just a decade ago, flaps and trim were usually manually operated; but today they are electrically powered in most aircraft. Autopilots, ADS-B receivers, XM weather receivers, multiple EFIS displays, AoA systems, and LED lighting are all commonplace today and must be wired carefully.

When you think about the wiring in your aircraft, think about it in two parts: (1) the power distribution system (including grounds), and (2) the data wiring. This article focuses mainly on the power distribution system, but the general thought process applies to all the wiring in your project.

Let's Get Started

It's easy to want to get going by drilling some holes, running some wires, and trusting it will all come together later on. But I advise taking a different approach: spend a good amount of time *up-front* planning all aspects of your electrical system before you even run or cut a single length of wire. This is important for many reasons, including the fact it will save you time, money, and headache later on.

Start by thinking about the big picture as you design your electrical system. It may not seem like it, but *you* are the systems engineer who is ultimately responsible for designing the correct system for your needs. The kit manufacturer usually has some general guidance, or you might find a few sample electrical system drawings on the Internet, but in fact those are only starting points. They are but one piece of data that feeds into the process of designing an electrical system tailored for you. You must do the work so you are assured that the process generates a plan that's right for your project, not for some other generic airplane. And don't forget, education is a key part of building your plane on an Experimental certificate. So look at this

as an opportunity to learn more about your future electrical system than you ever learned in the past from flying a certificated aircraft.

When designing your electrical system, there is a temptation to copy or do things the same way as your buddy did them when he built his plane. Avoid that temptation. Every Experimental aircraft is different and is used in different ways. It may end up that your plane, when finished, is similar in certain ways to your friend's plane; but that should be because your requirements are similar and not because you blindly copied him.

Here are three suggested steps to follow when starting to design your electrical system:

Step 1: Clarify Your Mission

In this age of gadgets it is all too tempting to add just one more enhancement, then one more again, until we lose sight of how and why we are building an airplane in the first place. Think about the most basic things first. What will your plane be used for, what type of weather will you be flying in, and what do the worst-case scenarios look like?

The outcome of this analysis drives not only how you wire your electrical system, but also what avionics and other equipment you put in the aircraft. Most Experimental aircraft are used for day/night VFR flights. If that's the case for you, do you really need multiple electrical busses, dual AHRS, dual radios, and similar redundancies?

Beyond just the flight conditions you anticipate, there might be other considerations as well. For example, if you plan to fly often with someone in the right seat who is a pilot or is interested in flying, then an EFIS on the right side of the instrument panel might be nice. It may not make sense as a backup for day VFR flight, but it might make sense because you want to share the experience with someone in the right seat.

Alternator selection is another good example. How electrically dependant is your engine and equipment? Would a loss of your alternator and continued short-duration operation on battery affect your safety? If you have a traditional aircraft engine and plan to fly mostly local flights, then a single alternator should be sufficient. But if you plan to fly cross-country flights or IFR, it may make sense to add a backup alternator. Do your own analysis, but I'll bet you can fly VFR all the way across the country on your backup alternator, as modern avionics and lights draw so little power.

Vertical Power has a simple questionnaire used at trade shows to help prospective customers walk through the thought process. It provides value because people can now see the beginnings of a design starting to materialize on paper. And if you're comfortable about the path you're going down, you'll continue on your journey. Yes, write down your thoughts and basic guidelines, and then use those continuously as a reference when you're deciding how to equip the aircraft.

If you clarify your mission, determining not only *what it is,* but also *what it isn't,* you will be ready to move on:

Step 2: Commit Every Detail To Paper

It is surprising how many builders, after relying on many pages of detailed plans for their airframes, use little more than a napkin or a single sheet of copy paper to draw out their electrical system. Planning and researching your design, and then committing every detail of that design to hardcopy before you buy equipment and run wires, will pay huge dividends later on. The documents will be used for purchasing, actual wiring, configuring the avionics, troubleshooting, future modifications, and will add value to the aircraft if you decide to sell it. I also keep a small binder of drawings in the aircraft, so if anything goes wrong while I'm away from home, the documentation is readily available.

Whether you're comfortable with either a pencil or a computer, keep records of everything somewhere. Use whatever tools work best for you—paper, PowerPoint, AutoCAD, and/or spreadsheets. Take pictures of electrical details you come across at fly-ins or online. Ask questions. Read installation manuals (which is especially valuable *before* you buy equipment, and most manufacturers have their

Getting your hands on the actual wiring and equipment can really help during the planning stage, especially if you haven't seen it before.

Neat, organized wiring is the result of lots of planning.

Photos: Marc Ausman

The backside of the circuit breaker panel should be neat and organized. You can start to see the results of all that planning.

manuals available online for free). If a manufacturer does not have their installation manuals available on the Internet for homebuilders, consider using a different manufacturer.

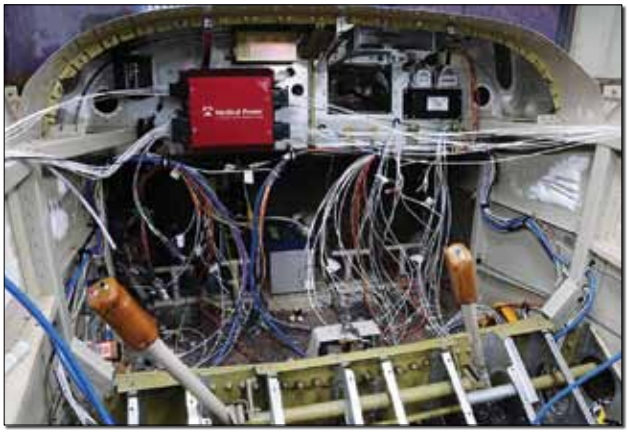
For many builders, while their airframe and powerplant are very close versions of work that has been done by countless builders before them, their electrical system will be somewhat unique. Even if you are following accepted practices for your design, and even if that design is as "standard" as the next guy's, you will probably discover that you must spend more time documenting the specifics of your electrical system than you did for any other part of the airplane.

Draw an outline of the airplane (top and side views, others as necessary) and indicate where each component is planned to go. Be sure to include each antenna, black box, contactor, fuse, motor (trim and flaps), pump, sensor, autopilot servo, light, alternator, main battery, backup battery, AHRS, magnetometer, OAT probe, fuse or electronic circuit breaker system, shunt, and other components. It really adds up to quite a lot of stuff. The only way to stay sane about it is to take it one item at a time.

Next you can draw a set of wiring diagrams (or one big drawing) showing how the power, ground, and data wires connect between the different boxes. Note that the focus of this drawing is to show the wiring interconnects, rather than the physical location of each box. It is simply a drawing with black lines between the various boxes. Label the lines as data or power or something unique to that installation.

Once you know how everything connects, you can draw detailed schematics of each sub-system. This level of detail includes wire types, pin out detail, connector identifiers, and shielding ground points. For example, you can make a drawing that shows only the trim system and another that shows just the flap system. Another can show the wing wiring and connector detail. Keep making drawings until everything is described in detail.

Important note: the data interconnects between all of the instrument panel avionics can be very complicated. One way to save time and reduce the risk of error is to have an avionics shop (particularly one that specializes in Experimental avionics) pre-wire and test the panel for you. Typically a dealer can also provide a schematic of the panel wiring.



(Left) Here's an RV-6 with most of the wires connected but not yet installed. You can see that having this well documented—and the wires labeled—is the only way to keep it organized. Just remember: one wire at a time. (Right) The same panel in the RV-6 with all the wires installed and working.

Along the way you'll learn a lot about your systems. Does the AHRS have a built-in magnetometer or is it separate? What restrictions are there regarding mounting of the fuel flow sensor? Does the EFIS have its own built-in backup battery or do you need to buy a third-party unit? Are there special considerations for strobe light wiring? Where does the marker beacon antenna wire go? This process will inspire you to talk with fellow builders, read the installation manual for each component, and become familiar with not only mounting issues, but also wire-sizing and circuit protection needs. For me, it's an exciting way to learn about systems in much greater depth than ever was possible with factory-built aircraft, and I hope you feel the same way, too.

It seems like a lot of work, but after helping hundreds of customers with many different designs, I've learned that it's much easier to erase than to rewire. Much cheaper, too! Perhaps the best result of a detailed paper design is that it encourages you to follow the most valuable maxim:

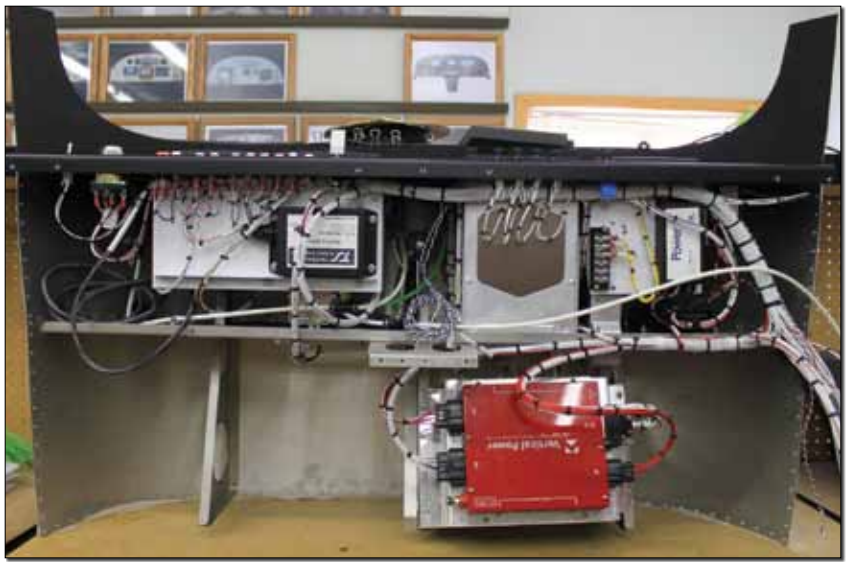
Step 3: Keep It Simple

As a basic rule, the more complex something is, the more likely it is to break. For some reason, while most Experimental airplanes are built as dependable but simple vehicles, their builders are enticed to attach every electrical bell and whistle they can find. By adding more relays, busses, terminals, diodes, wires, and (let's face it) *toys*, you are actually adding more things that can fail and more things that make it harder to troubleshoot.

Maybe you fly an airliner for work and you want your day-VFR RV-8 to have the same level of redundancy as your Boeing. Such a plan starts as the default only because that's what you're used to. But is it really necessary for the missions you fly in the RV-8? Your RV-8 and your 747 not only fly very different missions, they have very different teams building and maintaining them.

Perhaps the worst quality of a complex design is that it actually adds risk when it is intended to reduce it. Over the years, I've seen a tendency for people to want to over-engineer their electrical system to mitigate all possible failures. There is a misconception that the aircraft can't have any single points of failure. The reality is, the system should be designed so that if something fails you can continue to fly safely in the conditions you've anticipated based on your mission. For example, if you are analyzing the possibility of a primary EFIS failure, but you only fly local day VFR flights, then it is reasonable to expect you can return to your home airport and land safely. Therefore, a backup EFIS and power source are probably not needed. However, if you design for a possible EFIS failure while in IMC conditions, then it is reasonable to design a system with a backup EFIS and backup power source to mitigate that risk. It is not necessary that your backup systems perform every function of your primary systems.

The design of your backups, if needed at all, should be carefully pruned to give you that minimum set of features you *require* if one of your primary systems fails. Anything extra is likely to make your backup cumbersome, difficult to maintain, and less helpful when you need it most.



Here is the back of a professionally-wired RV-10 instrument panel. If this looks daunting to you (and it should), ask an Experimental avionics dealer about wiring the instrument panel and providing drawings for you. (Photo courtesy of Aerotronics.)

Wash then Repeat

Cycle through these steps as many times as necessary. After each iteration, go back to Step 1 and review whether what you've done still fits in with your original mission. If it does, congratulations! If it doesn't, it's early enough to change things because the design is still on paper. Leave it alone for a while and come back when your brain clears out a bit. Does your design still make sense?

Before you jump into the wiring of your airplane, please consider these three steps. The end result can be an electrical system and avionics package that meets your real needs when you get your project in the air. ✚

MARC AUSMAN

Marc is the president of Vertical Power and an EAA Director. He served with the U.S. Navy as a Naval Flight Officer on board the P3-C Orion and currently flies an RV-7 that he finished building in 2006.

Let's Split!

The secret behind opening the Lycoming crankcase.

BY RICHARD KEYT

For many years, I flew a homebuilt airplane with a Lycoming O-360 narrow-deck engine that was built and first flown in 1972. Several years ago we switched the case to a wide-deck version. During the 14 years that I have been flying the plane, both of these engines required teardown and rebuilding. Even with an interest and background in doing mechanical work myself, I was surprised at how difficult it was to separate the engine case halves during a teardown. I have been studying this problem and have learned a few things from the Internet and through talking with Allen Barrett at Barrett Precision Engines of Tulsa, Oklahoma and Harold Harris of Crankcase Services Inc. of Sand Springs, Oklahoma.

By the Book?

The Lycoming Engine overhaul manual has a section related to separating the case halves in section VII on pages 7-13. This page is dated January 1971 and is titled *Separation and Assembly of Doweled Crankcases*. The photographs in the overhaul manual depict a mechanic using Lycoming Tool #ST-122 Crankcase Pressure Plate. The Lycoming Special Service Tool Catalog describes this tool as appropriate for "all engines employing crankcase thru stud dowels." An Internet search for "separating Lycoming engine cases" found an excellent article—with many photos of an engine teardown—by Matt Throckmorton (DocThrock). His engine is a Lycoming O-540 wide-deck engine, which does not have "thru stud dowels" in the crankcase, yet he was using Lycoming Tool #ST-122. This confusion caused me to spend some time researching all of the different combinations of engines and which tools are appropriate.

Decks, Bolts, and Studs

I found that there were three different types of engines. The first were what is commonly referred to as narrow deck. Narrow-deck engines had flanges on the cylinder bases that were relatively thin. The flanges were reinforced by plates installed under the cylinder hold-down nuts and were curved to cover approximately half of the cylinder flange base. The cylinder hold-down nuts are internal-wrenching (like a twelve-point Allen

Fig. 1: Lycoming through bolts come in several different configurations.

wrench socket head cap screw). The diameter of the circle of bolts and studs that anchor each cylinder was slightly smaller on the narrow-deck versus the wide-deck engine. The through bolts on these engines were threaded into one side of the crankcase. Because they were anchored by being threaded into the case, they were referred to as "studs."

There are four different types of through bolts or studs used by Lycoming over the many years that they have been manufactured (see Fig. 1).

The top bolt in Fig. 1 is called a case bolt. The left side of this bolt has ½-20 threads to secure the flange of a cylinder. The right side has ½-13 threads and is installed at both the front and rear through bolt positions on a narrow-deck engine. The coarse threads are used to anchor this bolt to one side of the case. This same bolt is also used on the two aft positions of a four-cylinder wide-deck engine.

Lycoming started to make changes to their engines to improve them to what is now called the wide-deck engine in the mid 1960s. This process was completed in the '70s. A few changes generated what could be referred to as a "mid-deck" engine. The through bolt second from the top in Fig. 1 is from this era. It is a stud installed in the center position on both four- and six-cylinder engines before the issuance of SI-1123C. This stud has an enlarged center of 9/16 inch in diameter. This was an attempt to stop crankcase fretting. Notice that the right end of this stud has two sets of ½-20 threads. The threads on the extreme right end are for the cylinder hold-down nut. The threads further from the right end are to secure the stud to the case half.

Lycoming Service Instruction SI-1123C was a modification to the center through bolt positions that called for a counterbore in both case halves to accept a hollow dowel. The through bolt would pass thru this dowel. This service instruction rendered the second through bolt in Fig. 1 obsolete. The third stud in Fig. 1 has a reduced center diameter from number two, to allow it to pass through the new dowels. It also had an enlarged thread on the right end to anchor it to one side of the crankcase.

All three of these studs are anchored to one side of the case and therefore cannot be pushed or pulled all the way through the case. Lycoming's tool #ST-122 for separating engine cases is a pressure plate that pushes on these studs from the far side of the case. Lycoming has not manufactured an engine with this configuration since the mid '70s.

The fourth bolt in Fig. 1 is the one used on wide-deck engines. The center of the bolt has a ½-inch diameter, and is designed to be a close-tolerance fit on the case halves at the split line. This "body-fit" was adopted to prevent movement of the case halves relative to each other and thus prevent fretting. All eight of the through bolts on a six-cylinder engine are this type. The rear two through bolts on a four-cylinder engine still use the case bolt in position one of Fig. 1.

My description of all these different through bolt designs has been leading up to a discussion of how to disassemble a Lycoming crankcase.

Taking it Apart

If your engine is a wide-deck version, the through bolts that are not anchored to one side of the case can be removed first. This is done by threading a nut onto the through bolt with a stack of washers under the nut (Fig. 2). The nut that we use has a longer length than the standard cylinder hold down nuts. This gives us more thread engagement to prevent wearing the through bolt threads. As the through bolt is withdrawn, the stack of washers must be increased in height. All eight of the through bolts on a six-cylinder engine can be removed in this way. The front four through bolts on a four-cylinder

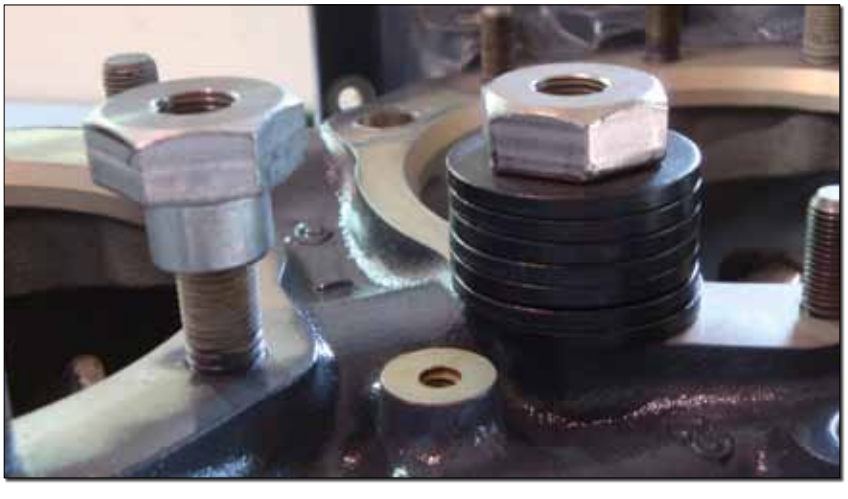


Fig. 2: A stack of washers can help remove the through bolts on a wide-deck engine.

Photos: Richard Keyt

Fig. 3: Plates can be used over the cylinder base holes to provide anchors for the case-splitting screw.

Fig. 4: The Acme screw with a V-block on the end to push on the connecting rod journals.

engine can also be removed in this fashion. Removal of the through bolts greatly decreases the forces involved in splitting the case apart.

The crankshaft seal at the front of the case is glued in place with Pliobond. Unfortunately, this can make the case difficult to separate because the seal will be holding onto both sides of the front of the case. This can cause a misalignment during separation of the halves that could damage the oil slinger on the crank. The front seal should be carefully removed from the nose of the case. Be very careful not to scratch the crankshaft surface that the seal rubs on during rotation.

At this point, Lycoming Tool #ST-122 cannot be used because it relies on the through bolts to force the case halves apart.

I asked a few shops how they separated wide-deck engines and found that they used in-house, custom-designed tools. Since I couldn't find these tools, I decided to build a set for myself.

A Tool is Born

My design works by attaching plates over the cylinder base holes using hold-down studs (Fig. 3). The plates have Acme threaded nuts to accept a large Acme threaded shaft with a V-block. This block can then be used to apply force to the connecting rod journal of the crankshaft (Fig. 4).

During the separation, the case must be monitored in two planes and kept parallel (Fig. 5 and Fig. 6) because Lycoming engines have an assembly pin that press-fits into both case halves in a different location from the through bolts (Fig. 7). These pins are not symmetrically located relative to the crankshaft. This means that the case halves will attempt to rotate around the crank during the separation (Fig. 8). To control this rotation, a clamp can be used to keep the case halves parallel as they separate (Fig. 9). During the case separation, the force required is a result of any remaining through bolts, the assembly pins, and the sealants used along the split line during assembly.

Variations on a Theme

All Lycoming engines are similar, but not identical. Likewise, they require similar, but not identical, plates to split the case.

- On a four-cylinder engine, the crank journals are all in the same plane. One threaded shaft and V-block will press on the near journal and the other presses on the far

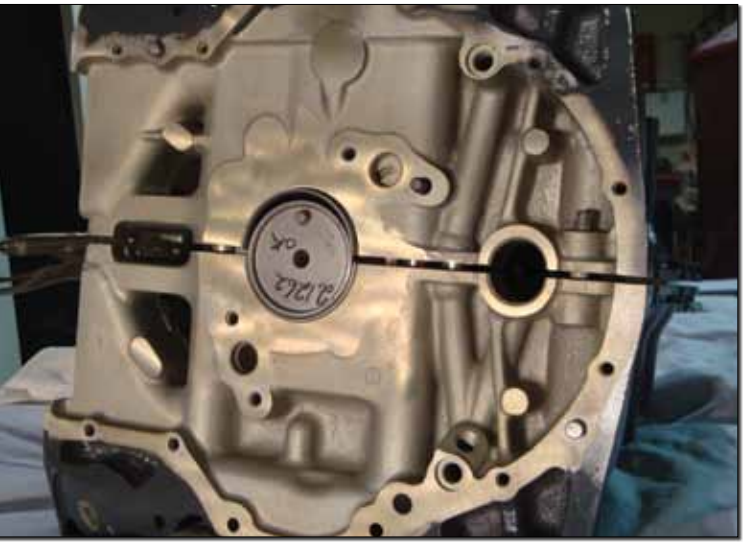


Fig. 5: The case halves must remain parallel during separation.

Fig. 6: Check parallelism in both directions.

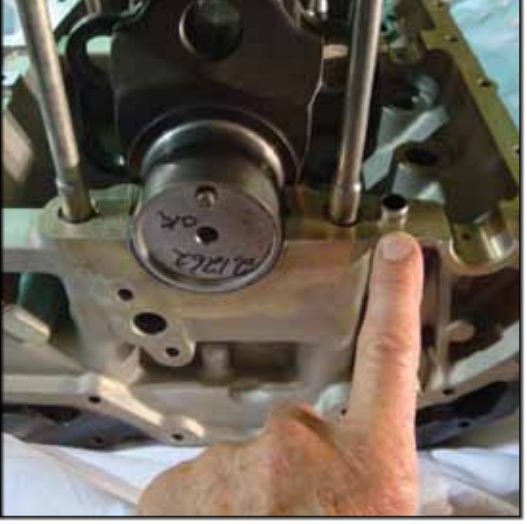


Fig. 7: The case will tend to rotate around these pins during separation.

Fig. 8: An example of the case halves not staying parallel.

Fig. 9: A clamp can be used to keep the halves parallel during separation.

journal. This engine requires two symmetric plates.

- On a six-cylinder engine, all of the crank journals are 60 degrees apart. This only allows pressing against one journal. Pressing on another one causes the crank to rotate, forcing the two case-halves to twist as they separate. The solution is to push on one crankshaft journal and one counterweight mounting "ear." So, this engine requires one symmetric plate and one assymetric plate (See Fig. 10).
- On an engine case assembled without a crankshaft, the case-halves need to be pushed apart without the crank. The solution is to mount a second plate on the opposite side of the engine using the cylinder hold-down studs. Because the cylinders are staggered from each other, the opposite cylinder hold-down hole is not in line with the opposing cylinder. This requires yet another specially designed plate, and it has a bearing that is located in-line with the screw from the opposing cylinder (Fig. 11).

Tearing down a Lycoming engine is one of those projects that can have extremely serious consequences if it's not done right. Like so many other aspects of maintaining a homebuilt aircraft, the results are always better when you use the right tools—even if you have to make those tools yourself.

For additional information, contact Richard Keyt, Ryan Machine, 9608 Taxiway Dr., Granbury, TX 76049, 817-573-2786, info@ryanmachine.net.

Fig. 10: Different plates need to be used for six-cylinder engines due to stud configuration.

Fig. 11: Another special configuration is used if there is no crankshaft in the case.

The Tool Set

Splitting the case of a Lycoming is difficult enough, without having to also build the tools. If you're looking for pre-made tools, the author offers a complete set, which includes:

- **Two symmetrical plates for use on a four-cylinder engine.**
- **An asymmetrical plate for use in pressing on the counterweight ear of a six-cylinder engine while using one symmetrical plate on a crankshaft journal.**
- **Two plates to be used if the engine does not have a crankshaft installed.**
- **Custom-made nuts and heavy-duty washers that utilize the full threads of the studs when anchoring the plates to the case.**
- **Two Acme-threaded screws that attach to the V-blocks for pushing on the crankshaft journals.**
- **A carrying case to keep all of the pieces organized.** ⊣

—R.K.

No Trip to the Mall

The homebuilt insurance shopping experience.

BY JENNY ESTES

"I'm shopping for insurance."

We hear this phrase all the time, but what does it really mean when it comes to protecting your plane—whether it's still in hundreds of pieces or it has hundreds of hours in the air? It's not like you'll be taking a trip to the airplane mall and comparing makes, models, colors, and sizes.

The answer is very different, depending on if you talk to a consumer—you, the pilot—or an insurance broker. For you, the person who needs a policy, it probably means you think you're going to talk to a bunch of people and find the best price. But for a broker, it means that you're going to talk to a bunch of insurance companies and find a bunch of different options for the kit builder who wants aviation insurance. And for better or worse, you, the aircraft owner, can't talk to those companies by yourself.

Aviation insurance occupies a very specialized niche in the market, so you don't enjoy the same level of options as you do for, say, life insurance or auto insurance. Only one insurance underwriting company quotes directly to you as the insurer. Every other aviation insurance provider requires that you work with an aviation insurance broker. As a result, when you are shopping for insurance, you are actually shopping for a broker. And then, your broker becomes your designated shopper, charged with finding the best insurance company and the best policy for your needs.

All About the Broker

Even as an educated consumer, it can be hard to tell what qualities to seek in an aviation insurance broker. Overall, you can't go wrong with a broker who specializes only in aviation—that means they're experienced in the area that matters most, and have access to all the aviation insurance underwriters out there. Look for a broker who is knowledgeable about all aircraft, but especially the type of aircraft you own and are building. Not all brokers understand kit aircraft, so make sure to look for a broker with plenty of experience in this area of specialty aircraft. If they have never heard of anyone who actually builds the aircraft they fly, then that's not a good sign.

What's more, make sure your broker knows the insurance companies well and understands what their policies cover. Does the policy offer hurricane reimbursement fees? Does it cover the transportation of your aircraft if you have a precautionary landing and do not damage the plane, but are unable to take off? Do you have coverage to fly non-owned aircraft? Do you have premises liability coverage that extends to the area around where your aircraft is stored?

So how do you find this broker? You can search online or check the manufacturers' web sites to see if they have a certain broker they recommend. You can also check on specific aircraft forums online and see who other builders are using. Last, but not least, ask your friends. Referrals go a long way! If your friends are getting great service and trust their broker, then you probably will, too.

What does a broker do?

Your broker's first job is to shop all the appropriate insurance companies for you each year when you buy and then renew a policy. If your broker only gives you one option, we suggest you ask them what other insurance companies they approached, and find out if they received more quotes.

A broker's other job, equally important, is to place you with strong and stable insurance carriers. At this time, eight different insurance companies insure kit aircraft. Each company may not write every kit on the market, but this is a higher number than a few years ago, when only four or five insurance companies would insure kit aircraft. Occasionally, we see new insurance underwriting companies that debut with very low rates in order to build their business, but then fail in just a few years. In the aviation insurance world, if something seems too good to be true, it generally is. Your broker should put your best interests first; and while price is important, it's not always the most important criteria when finding a carrier. Choosing an underwriter with the lowest price is not always the best option.

Once you have found an insurance broker, there is no need for you to call

Insurance isn't just for flying—many builders insure their projects so that if their home or shop burns down, they can recover (financially) and begin again.

There's No Such Thing as a Stupid Question

Aviation insurance is complex, and not exactly a topic you deal with every day. Don't be afraid to ask your broker plenty of questions until you feel you understand everything involving your policy. A few common questions:

Why won't my similar aircraft time be counted as make and model time for this aircraft?

Most insurance companies will take similar time into effect to lower or remove dual requirements, but as far as rates go, they can only count same make and model aircraft. The exception to this rule comes with the Vans aircraft series; a few carriers will accept all RV-6A, 7A, 8A & 9A hours as the same, and also handle RV tailwheel models accordingly. The RV-3, RV-4, RV-6, RV-7, RV-8 and RV-9 are lumped in the same category. The RV-10 and RV-12 are in a class of their own.

My hangar/airport has extra security: security cameras, a fence, a fire hydrant, etc. Will this get me a discount?

No, this will not get you any discounts. Insurance companies will ask if your aircraft is hangared or tied outside. If it is hangared, you will get a discount. They will also look at runway type (paved vs. turf) and runway length, but they don't look at the actual hangar/airport and any extra safety features it may have.

I am 70 years old. Can I get coverage?

Yes, however you may have to pay some additional surcharges and you may not have as many options as younger pilots. Most carriers will not write a new policy for pilots older than 75, but a couple insurers will quote new pilots up to 80 years old, if the pilots have the appropriate hours. Once you hit your 70s, it's not wise to let your policy lapse, or you may not be able to get coverage again.

What can I do to get a discount?

The first two things are obvious—fly safely and keep your insurance history free of any claims. But beyond that, a few companies give discounts for belonging to AOPA and successfully completing the FAA's WINGS Pilot Proficiency program. They also may provide a higher level of coverage for EAA members. Your broker should know which companies give which discount; if they don't, you may not be with the right broker.

Insurance policies are very complex and not the easiest to read and decipher. Don't be afraid to ask your broker questions; that is why they exist. And if they will not or cannot answer your questions—well, maybe it's time to start that shopping process.

—J.E.

Photos: Jenny Estes, Louise Hose

When the skies turn dark and your airplane is outside, good tiedowns are important—and good insurance will give you peace of mind.

another one each year, as long as you have built a trusting relationship. Your broker will be doing all the shopping for you.

Policies

Once you select your broker, you can concentrate on the many different types of insurance policies and coverages that you can choose for kit aircraft. A qualified broker will help you understand each policy type, explain the differences, and help you decide which is best for you. More complex aircraft/engine types are going to be harder to insure and your broker may only find a few options for them, so not every type of insurance we review will apply to your aircraft. Again, check with your broker.

Builder's insurance

Many kit aircraft builders think this type of coverage is a waste of money. But ask yourself: If you've put so much time and work into this aircraft, shouldn't it be protected? Did you know that most homeowners' policies will not cover the aircraft kit and parts? It would be a very sad day if a storm or fire came through and destroyed your almost-completed Glasair. One of the more chilling stories we've heard about builders' risk involved a runaway car crashing into and damaging a row of storage garages, almost hitting the client's garage with his aircraft wings tucked inside. This very close call made the builder call and get coverage on his project—if it happened once, it could happen again.

But again, always discuss the policy thoroughly with your broker. For example, when you are pursuing a builder's risk policy, make sure the engine type you plan to use is approved by the insurance companies, and that they will insure the aircraft for flying coverage with the engine type you are using. Many carriers frown on auto engines.

It's also a good idea to learn how many hours you will need for the type of aircraft you are building, so you will be prepared.

Currently, affordable builder's policies are available from three different insurance companies. They offer no deductible for not-in-motion losses. You can choose to cover just the physical damage of the kit, or you can add liability coverage, too. Some airports require liability coverage to store your kit in their hanger. Builder's risk policies may also cover transportation of your aircraft—to the airport or paint shop, for example.

What's more, builder's policies allow for the changes that are a part of the kit process.

At the high end of the game, insurance will be driven by pilot requirements and qualifications, as well as aircraft value. This Lancair Evolution is both high priced and high performance.

They provide coverage if you keep your kit in several different locations; you can have the engine at your house, the wings in a storage unit, and the tail kit at the airport and it will all be covered.

Similarly, you may be able to get a policy that will insure the plane at two values. This policy type is best if you know you will be adding some more items to your aircraft in the near future, and you don't have to worry about calling your broker to increase the value—unless it goes above the ending amount. For example, you can set the policy coverage to have a starting value of $40,000, with coverage that automatically covers up to an ending value of $80,000. You determine these insured amounts, but your broker can guide you about setting them.

Liability coverage is another option, although I'm sure you are wondering why you need liability protection on a plane that's in pieces. Beyond airport requirements, liability coverage protects you if anyone helping you build the aircraft is injured, or if you're transporting the aircraft and a wing falls off and damages a car, to name a few real-world occurrences.

Preparing for Flight Insurance

Once you have completed the build process and received your airworthiness certificate, you're ready to upgrade to flight insurance. Make sure your pilot certificates and hours meet the minimum requirements for the aircraft you have built. Four insurance companies will cover the plane during the Phase 1 test period. These carriers require that the pilot has at least a Private Pilot Certificate unless you are in a more complex aircraft; then you may be required to hold an instrument rating as well.

For most non-complex, fixed, tricycle-gear aircraft, underwriters require at least 100 total hours. For some higher-horsepower or uncommon models, this number could be higher. If you've built a turbine kit plane, for example, the number of hours required will increase dramatically. For most non-complex, tailwheel models, insurers require 200 total hours, including 25 tailwheel hours.

Plan on transition training if it's available for your make and model aircraft. Typically, if your kit aircraft has tandem seats, an insurance company will accept the training in a side-by-side version of the same or similar aircraft. However, transition training may not be available for some Experimental aircraft. If this is the case, then your broker will work with the insurance company to accept another training plan. For example, we've had underwriters accept non-CFI pilots to give dual training when they

Lessons in Liability, Courtesy of Mother Nature

Want to make sure you get a good night's sleep? Read an insurance policy. We're the first to admit it's pretty dry stuff—until something forces you to understand what it means. While the infamous Sun 'n Fun 2011 storm may be old news, its lessons bear repeating.

Mother Nature demonstrated the limits of liability-only and the importance of ground-not-in-motion coverage, plus the meaning of quality service, when an EF-1 tornado developed out of a storm already belting the event with 75 mph straight-line winds. More than 40 aircraft were destroyed or damaged. Some homebuilders saw a lifetime of work reduced to rubble. Team AeroDynamix, the aerobatic team comprised entirely of Van's RV aircraft, lost several planes.

A few things we learned:

1. **Liability-only coverage has its limits and ground-not-in-motion coverage is worth the money. When some other guy's airplane is flipped on top of yours and the insurance company classifies the tornado as an act of God, you're not going to get any money if you have a liability-only policy. When a trash can comes barreling into your tail and leaves behind a big dent, *you're not going to get any money.* When your nosegear collapses and your plane does a face plant. . .you get the idea.**
2. **Being there matters. If you were lucky enough to have a broker attending Sun 'n Fun—and I wasn't the only one there—the claims process started almost immediately. Without exception, homebuilders with brokers on-site enjoyed the fastest turnaround times on their claims.**
3. **Your broker should serve as your advocate for unusual circumstances. Show organizers rushed through post-storm cleanup to get programming up and running. In some cases, aircraft owners were stuck with a cleanup tab of thousands of dollars for removals and cleanups they didn't even authorize. Many affected homebuilders got those costs paid after their brokers petitioned the underwriters.**
4. **A quick response time from underwriters matters. Team AeroDynamix was able to replace their lost aircraft within a few weeks to continue their busy show schedule without a hitch.**
5. **As brokers, we cannot understand what it means to experience a claim until we're in the middle of it. It's just as important to offer emotional support as paperwork.**

—J.E.

Bad things can happen to your airplane, even when you're not at the controls. Knowing that you have a good policy can let you sleep better when away from home.

have the appropriate experience in the same aircraft type.

The next step is to wade through the many forms of available coverage. Again, a qualified broker is there to help you make these decisions. Below are the most popular policies for kit aircraft pilots.

Full Coverage insurance:

This policy gives you the most protection, as it covers your aircraft for physical damage coverage at all times while parked on the ground, during taxi, and in flight. Liability is, of course, included in this policy.

Ground and Taxi Coverage:

This policy type covers physical damage to the aircraft while it is parked and not moving, and offers taxi coverage up to the active runway. Once the aircraft enters the active runway, you no longer have in-motion physical damage coverage, only liability coverage while flying. Physical damage coverage starts back up once the aircraft exits the active runway and is once again taxiing.

Ground-Not-in-Motion Coverage:

This policy type only covers your aircraft against physical damage while it is parked and not moving under its own power. There is no physical damage protection, only liability coverage, at any time when the aircraft is powered up, taxiing, or flying.

When insuring a priceless piece of history (like the RV-1, shown here in the EAA Museum) for actual flight, it takes a creative insurance broker and company to come up with a policy that is affordable, yet flexible. In this case, numerous pilots had to be accommodated and qualified to ferry the airplane to shows.

Liability Only:

This one is self-explanatory—you are limited to liability coverage, with no physical damage protection at any time.

Notice that we haven't reviewed any sections about broker-generated rate changes, discounts, or extra fees. That's because they don't exist. You should get the exact same quote from different brokers, as long as you are providing them with the same information, and it is submitted the same way. This is why brokers ask you to sign a "broker of record" agreement, to prevent duplication. Your best bet is to find a broker you trust and whose service makes you happy, and then stick with him or her.

And that's your trip to the insurance mall. As in any mall, the choices may seem dizzying, but when you shop with good advice and a plan of action, you can survive—and even enjoy—the experience. ✚

Special Handling–Insuring the RV-1

It took four years to restore the RV-1, from the time it was found in Houston, to the time it was ready for flight. Finding a way to insure the plane, and getting the policy in place, was the final hurdle to beginning its "victory tour."

When this first came across for a quote, I was ecstatic to get to work on the original Van's aircraft. And finding coverage was not as difficult as I thought. It just took a little creativity.

We were able to get U.S. Specialty Insurance Co. to insure the aircraft with an unlimited number of pilots, as long as they were approved by the chief pilot named on the policy. This is not common in Experimental aircraft policies; most are for named pilots only. Having a named-pilot-only policy on the RV-1 would have made the journey across the United States very difficult, if not impossible. It helped to have a chief pilot with a reputation for risk management—KITPLANES® Editor Paul Dye!

By allowing the Chief Pilot (a.k.a. Paul) to approve the pilots who would fly the RV-1, we could ensure the RV-1 team could use a string of pilots on the RV-1's tour of 12,000 miles, with 35 to 40 stops, from Florida to Canada. About a dozen pilots were involved in the tour. The journey ended in Oshkosh at EAA AirVenture 2012 when Dick VanGrunsven (also approved by the Chief Pilot) flew his RV-1 to the show with the parade of RVs, which included one of each RV type. The aircraft was then donated to the EAA Museum, where it will be kept in flying condition and inspire future builders for the rest of its time.

—J.E.

JENNY ESTES

Jenny Estes, sales manager of the Light Aircraft Branch of NationAir Aviation Insurance, has been involved with kit aircraft both personally and professionally for most of her life. Jenny grew up watching her father build several kit aircraft. She has played an active role in expanding NationAir's programs for Van's RV and Lancair aircraft, and speaks regularly about insurance across the country.

The One-Two Punch

BY DAN HORTON

Having trouble placing drilled holes exactly where you want them? Give them the guidance they need with the old one-two…a prick punch followed by a center punch.

What's the difference? The business end of a prick punch is sharpened to a fine, acute point, much like a sharpened pencil. The center punch is ground to a wide, flat angle, perhaps 140° total, a little more than the typical 135° drill point (Fig 1).

The sharp prick punch sets the precise location. Place it exactly where you want the hole (using a magnifier if necessary), then lightly tap with the hammer. The resulting mark (Fig 2-a) guides the center punch, which forms a low-angle dimple (Fig 2-b), which guides the drill (Fig 2-c).

Fig. 1

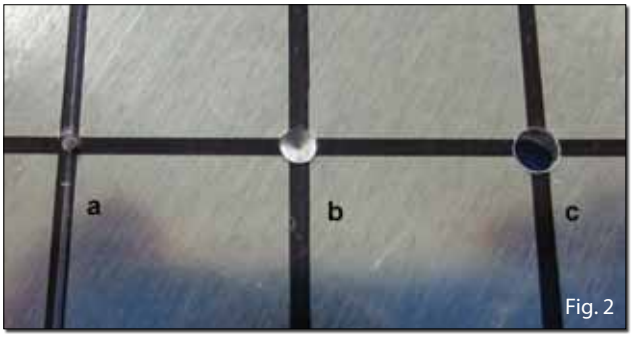
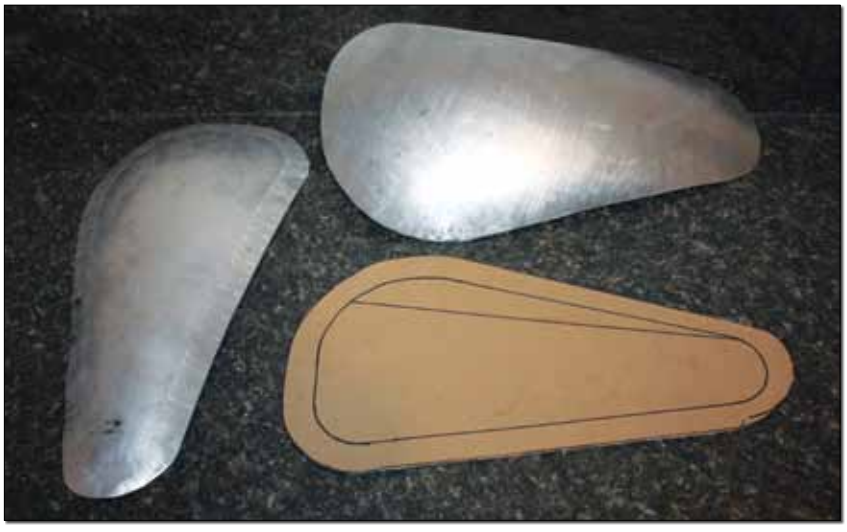


Fig. 2

The mysteries of the English wheel.

As many fabricators will admit, there's something mysterious and magical surrounding the English wheel. While teaching an aluminum-forming workshop at AirVenture, as I was tracking over 3003-H14 .063-inch aluminum, passing the material back and forth through the English wheel, an individual commented, "That machine is like a Ouija board."

Indeed, as the metal begins to stretch and form a dome, it does seem to take on a life of its own. But when the workshop attendees try their hand at tracking, they quickly realize this isn't magic—it's a skill. With practice, the English wheel makes it possible to transform flat sheets of metal into finished parts with compound curves.



This wheelpant was cut from a cardboard template, annealed, and shaped in the English wheel.

Easy as Pie

English wheels have been in existence for over 100 years. They are commonly used in the United States in the custom car and aircraft industry. But how do they work?

Imagine a baker is making a pie crust. (In our case, we're making a fairing or wheelpant.) As the baker mixes the ingredients, dough is created. (In metal forming, flat sheet aluminum or steel is the dough.) The dough is transferred to a flat counter, sprinkled with flour, and rolled out using a rolling pin. (In our case, the English wheel is our rolling pin.) As a baker rolls the dough, it becomes thinner and wider. (As we track with the English wheel, the aluminum or steel becomes thinner and longer.) The shape we create is determined by our anvil wheel selection and the amount of pressure we apply. (We'll look at this in greater detail in a few moments.)

English Wheel Basics

An English wheel can be broken down into four major components: frame type, roller wheel, anvil wheel, and adjusting mechanism. The photos show a fabricated benchtop style machine. Notice that the frame looks similar to a "U" or a "C" shape. This machine is referred to as a fabricated benchtop style because the machine is manufactured using square tubing, rather than cast iron. Although

Anvil wheels are available in a wide range of radii. From left to right: 2.50r, 3.75r, 6.00r, 12.00r, 24.00r and flat radius.

Mark Lynn

Mark first started machining, welding, and fabricating metal when he was 16 years old. He works in sales for a well-known manufacturer of metal fabrication equipment and is also a single- and multi-engine pilot. For the past three years, he has conducted seminars on metalworking at AirVenture.

many styles of English wheels are in use, the fabricated benchtop style is the most common. Versatile yet affordable, these machines suit any skill level.

The benchtop frame is produced by cutting mild steel tubing to size and welding it together in a welding frame. This assures the frame will be square when finished. Benchtop style machines can be mounted in a vise or placed directly on a workbench or floor stand. Stiffener braces may be added to keep the frame from flexing while working with 16-gauge material or thicker. A common misconception is that the frame needs to be completely stiff. While some stiffness is required, the material you are shaping responds to the pressure exerted between the roller wheel and the anvil wheel.

Another style of wheeling machine is the fabricated floor model. This style offers a larger throat depth (the distance inside the U- or C-shaped frame), making it possible to shape larger panels. Obviously, the larger throat depth means a larger footprint (the space the machine requires in the shop). We will take an in-depth look at floor model machines in a future article.

Some manufacturers also offer "U-weld" kits. With this type of kit, you supply the material for the frame, and the kit includes the lifting mechanism, roller wheel, a set of anvil wheels, and a detailed instruction manual for construction. This is a great way to save a bit of hard-earned money, while using your own frame design and welding skills.

Fabricated benchtop style English wheel mounted on an optional floor stand.

Roller wheel (top) and anvil wheel. The gap between the wheels has yet to be set.

Speaking of costs—like any hobby equipment, the price of an English wheel will vary. They may be purchased for as little as $300, or you can spend thousands of dollars; bear in mind that cost is relative to quality.

Just Roll with It!

Are you thoroughly confused yet? Thus far, we have discussed what the English wheel is and how it works. (Remember the baker and the pie dough?) We know that the U- or C-shaped frame can be manufactured from tubing or cast iron. And we looked at fabricated benchtop and floor model machines.

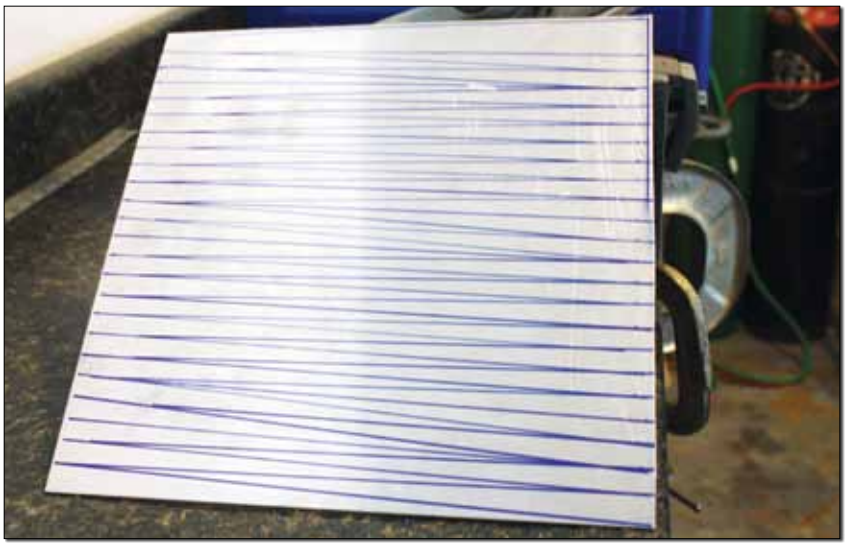
The next component we'll cover is the roller wheel, sometimes referred to as the top wheel. This wheel is manufactured from 1045 steel and measures eight inches in diameter by three inches wide. The width of the roller wheel may vary from manufacturer to manufacturer, but the surface will always be completely flat, unlike the anvil wheel, which is usually domed.

The roller wheel may be mounted on an axle (benchtop model) or, in the case of a floor model, a yoke (a U-shaped wheel holder). One advantage of the axle mount is that the craftsman is able to

With a "U-weld" kit, you supply the material for the frame, and the kit includes the lifting mechanism, roller wheel, a set of anvil wheels, and instructions for building the frame.

MetalAce 44F Floor Model English wheel.

Photos: Becky Lynn and courtesy of MetalAce



Layout lines are spaced one-half inch apart on this one-square-foot piece of 3003-H14 .063" aluminum. Notice the diagonal tracking lines between the layout lines.

Moving the adjusting mechanism handwheel closes the gap between the roller wheel and the anvil wheel.

rotate the wheel by hand, allowing better control in a confined space. The roller wheel will spin freely 360 degrees.

The next item we'll look at is the anvil wheel, often referred to as the lower wheel. Like the roller wheel, it is manufactured from 1045 steel; however, the dimensions are likely to vary. The anvil wheel is always mounted on the lower C- or U-shape of the machine in the yoke. Pressure adjustments are made between the anvil and roller wheel by way of the adjusting mechanism. The adjusting mechanism is comprised of an Acme screw and a handwheel. To increase pressure, rotate the handwheel clockwise; to lower the pressure, rotate the handwheel counter-clockwise. A press-fit roller bearing on the inside diameter allows the anvil wheel to spin smoothly. A precision-ground pin acts as the axle the anvil wheel rotates on. The benchtop machine uses a two-inch wide anvil wheel. Floor models use a three-inch-wide anvil wheel.

Now we move on to the radius of the anvil wheels. Radius doesn't refer to the diameter of the anvil wheel. It refers to the curve of the surface on the edge of the wheel. Benchtop machines usually come with a 3.25-inch radius anvil wheel only. Wheels with a 1.0-, 2.5-, 5.0- or 8.5-inch radius are offered in a complete set or individually for purchase. Flat-radius anvil wheels are also available.

Two questions I'm often asked are, "How many radius wheels do I need to have on hand?" and "What radius do I use for a particular application or project?" These are both great questions and we will look at them in detail in future articles. My usual recommendation is to purchase a complete set of wheels, both for initial cost savings and to increase a machine's capability. I would be disappointed if my motivation showed up on a Saturday night, only to find I did not have the correct radius anvil wheel for the job.

Plan Your Track, Track Your Plan

We now have an understanding of the roller wheel and the anvil wheel. And

When properly adjusted, there is a small gap between the roller and anvil wheels.

Beginning the lawn-mowing tracking pattern; low pressure settings control the amount of "stretch" in the work.

Look closely at the aluminum between the roller wheel and the anvil wheel. You can see a subtle dome in the material.

we know there are many anvil wheels to choose from. It's not difficult to see how the material begins to take the shape of the anvil wheel selected. As pressure is added, the metal stretches and begins to dome upward.

To achieve a uniform stretch and dome, you must decide what tracking pattern you will use. This also ties into "steering" the English wheel. One of the most common tracking patterns is often referred to as the "lawn-mowing" method. As the name implies, you pass the material back and forth, from one side of the panel to the other. You can move from the left to the right side of the panel; or you can move from the right to the left. I encourage beginners to spend plenty of time on this step. Purchase your first sheet of material and dedicate most, if not all, of this material to familiarize yourself with the machine. Characteristics of "steering," die selections, and pressure settings of the machine will be greatly enhanced with more practice.

Follow these steps closely:

1. Shear a one-square-foot piece of material.
2. Using dots, lay out 0.25-inch to 0.50-inch lines both fore and aft and left to right.
3. Now connect the dots with solid lines between the fore and aft. (Do not connect the dots from the left to the right.)
4. You now have guidelines to track.

This is an exagerated example; however, you can see the large amount of shape in this panel.

5. Choose an anvil wheel and install it into the yoke of the machine.
6. Close the gap between the anvil wheel and the roller wheel; insert your material and begin tracking.

Once you work from left to right, repeat the step from right to left. Pay particular attention to your tracking; you do not want to track too far fore and aft and run off the material. After this is completed, turn the panel 90 degrees and repeat the aforementioned step. You have just completed your first set of tracks.

See, that wasn't too difficult. In addition to your first set of tracks, notice that your one-square-foot piece has shape in both directions—fore and aft and left to right. Also notice that the center of this piece has risen about 5/8 inch. This is because you have stretched (and thinned) the material with the wheel.

Other tracking techniques include a star pattern for round pieces, and the staggered stop technique for larger panels. Resist the temptation to tackle extremely complex shapes at first. This will be a frustrating experience and may cause a complete loss of interest in future shaping projects. As you become proficient, tracking will become second nature. This early stage is when you will need to practice and refine your skills.

Keeping your part symmetrical and smooth is of the utmost importance. Make sure that you are following your guidelines and make subtle adjustments as necessary. If you notice too much crown in the center, you can wheel around the edges to raise that area. You cannot take the shape out of a part by flipping the panel upside down and wheeling over that area.

From time to time, you may need to pull the material out of the English wheel and readjust the panel on the bench. Push the sides and edges down, or twist them for a bit of adjustment. Again, the more you practice, the more proficient you will become.

Learning with Ron Covell

Now that you understand basic tracking patterns, and what problems to look for, what can you cut out and shape? A great resource and an individual that I have learned a lot from is Ron Covell. Ron offers workshops throughout the United States, as well as internationally. I recommend purchasing his video entitled *English Wheel Techniques*. This video is a great companion to the workshop. You can walk through the process on your own English wheel as Ron demonstrates each fundamental task. Check out *www.covell.biz* for a complete list of workshop locations. Also keep practicing on simple projects. There is nothing mysterious about the English wheel, once you see what it does and learn how it works. ⊣

PRACTICAL ELECTRICAL

Wire termination science—part III.

This is the third and final article that explores the art and science of terminating wires. The first article discussed mechanical crimps that strive for a "gas tight" connection between wire and terminal. The second article discussed joining of wires by soldering.

Crimp or Solder?

Crimped joints are simple, convenient and perhaps less demanding; soldered joints are functionally equivalent. Enthusiasm for crimped terminations has prompted poorly deserved criticisms of the soldered connection. For example: "Crimping is preferred to soldering because it's hard to keep the solder from 'wicking' out under the wire's insulation, making it vulnerable to breakage." In fact, if solder does flow out of the joint onto the wire strands, the installer has simply used too much solder. It is also true that stranded wire is more flexible and less prone to vibration-induced failure than solid wire. Converting stranded wire to solid wire by filling voids between strands with solder is indeed counterproductive with respect to vibration immunity.

Flexibility of a wire is severely constrained when the strands are all soldered together at the joint. But consider this: Are the strands any more flexible when joined to a gas-tight junction by crimping? Both soldered and crimped joints force a stranded wire to become quite solid. Any flexing of the wire in the immediate vicinity of the joint induces a lot of stress on individual strands. If the wire is going to fail due to vibration-induced stress, it will do so right at the transition between the joint and the free strands. It matters not whether the strands are constrained in a soldered or crimped joint.

In Part I of this series, I spoke to a feature of insulated crimped terminals called the "insulation support." The single-stroke terminal installation tool puts *two* crimps on each installed terminal (Fig. 1). One crimp is on the "wire grip" barrel, where a gas-tight connection is made between wire and terminal. The second crimp is further back on the "insulation grip" area, where the terminal's insulator is deformed to support the wire's insulation.

Fig. 1

This feature is easily added to joints at solder lugs. Heat-shrink tubing applied over the joint and extending a half-inch or so onto the wire adds the recommended support (Fig. 2).

Where to Solder?

Most owner-built-and-maintained (OBAM) aviation projects will have at least a few


Fig. 2

soldered connections (Fig. 3). These include, but are not limited to, headset and microphone jacks and plugs, miniature toggle switches and push buttons, and some full-sized toggle switches.


Fig. 3

If you're comfortable with the tools and processes, you might elect to use solder-cup D-sub connectors on your avionics (Fig. 4). They're a whole lot less expensive than the connectors with removable crimped pins.


Fig. 4

Robert L. Nuckolls, III

Bob Nuckolls retired from Beech Aircraft in 2007 after more than 45 years of work in certificated aviation and over 25 years of support for the homebuilt aircraft industry. Bob publishes "The AeroElectric Connection" from his web site at http://aeroelectric.com.

He also hosts the AeroElectric-List on Matronics.com. This special-interest forum serves approximately 1600 participants.

Photos: Robert L. Nuckolls, III

The TED 9-30-10 self-centering, coax tray connector (Fig. 5) used on many radios must be soldered.

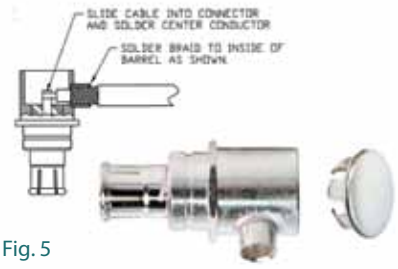


Fig. 5

DIY electronics projects (Fig. 6) will no doubt assemble with solder.

Fig. 6

In the factory environment, crimping is indeed preferred to solder. Crimp tools properly sized to terminals and wires are fast, semi-automatic, and low risk. On the other hand, a hot soldering iron is itself a risk for personal injury. Poor technique can produce bad joints or perhaps drip molten solder on the carpet (or into your shoe!). When soldering is the only option, here are a few tips for selection of tools and materials you'll find useful.

Solder 101

Let's talk about solder first (Fig. 7). As I mentioned in Part Two, the solder of choice is 63% tin and 37% lead—or 63/37. Yes, the world is migrating away from lead everywhere, even when its presence has no significant effect on the state of the planet. However, due to problems with "tin whiskers" and greater tendency for joints to crack under vibration, high-reliability military and aviation systems are not yet making the transition to lead-free solders.

Fig. 7

You can obtain 63/37 solder from most electronic supply houses and in quantities from one pound down to a few ounces on eBay. There are many capable suppliers of solder, but name brands like Kester, Ersin, and Alpha Metals are always a good bet. In a pinch, 60/40 alloy is close enough. For many of you, a one-pound spool of solder is a lifetime supply…and pretty expensive. Numerous vendors on eBay offer small quantities of 63/37 at attractive prices (Fig. 8).

Fig. 8

Removing Solder

Here is a very useful product to have in your soldering toolbox. This and similar products go by the name of "solder wick" (Fig. 9). All examples are made as a flat braid of fine copper wire coated with a good flux. This is used to *remove* solder from a joint. It's very useful when cleaning up the soldered terminals of a switch or cleaning out the holes in an etched circuit board to replace a part.

Fig. 9

There are lots of wanna-be solder wicks. Some are quite good, others are disappointing. The disappointments are made from wire that is too large and/or coated with a poor grade of flux. Chemtronics, NTE, and Solder Removal Company are good bets. I'm not implying that there are no able competitors. If you have an opportunity to try out a "good buy" off of eBay, it's a low-risk adventure. Pitch the stuff and try something else if your solder wick experiment doesn't quickly and cleanly soak up molten solder like a dry sponge.

Buying an Iron

Few tools come in more styles and qualities than soldering irons. Electric irons are available in battery-powered, portable configurations, as well as plug-in-the-wall wands. The most useful irons will have some means of controlling temperature, with the best being thermostatically controlled (Fig. 10). You can spend anywhere from $4 to $500 for a soldering iron. However, with a little practice you can probably solder all the necessary joints on your project with any of the aforementioned devices. Soldering well is more about materials and skill than tools. A high-dollar soldering iron will help you do a better job, but it cannot compensate for lack of practice.

Fig. 10

I probably own a couple dozen soldering tools, but if you're wanting to own only one, then I'll suggest a plug-in-the-wall wand from RadioShack or off eBay (Fig. 11). Sixty watts is *plenty*…25 probably adequate for the small solder jobs ahead.

Fig. 11

Installing the fat terminals described in Part Two calls for more heat—a miniature torch is handy (Fig. 12). There are a variety of gas-refillable irons/torches. Firing up a butane torch in a hangar with fueled airplanes about might seem a bit risky. Know that the butane-powered irons have no open flames after they warm up. Right

after you light them, there will be open flame for a minute or so until it warms up. At operating temperature, the flames go out and combustion is totally constrained within a chamber at the base of the tip.

Fig. 12

Iron plating of the tip is something to look for on all soldering irons. Unplated tips will dissolve into your finished joints and requires re-shaping with a file. You'll also want a tip that comes down to a sufficiently small diameter to work the pins in a D-sub connector—something on the order of .050 inches.

My personal favorite soldering irons are made by Metcal (Fig. 13). These are top-of-the-line tools with very accurate temperature control. They're only rated at 30 watts, but they deliver virtually all of that power available right at the tip. Further, there are dozens of tip styles in two temperature ranges. New Metcal solder stations are priced in the hundreds of dollars, but eBay is a great source for used solder stations and replacement parts for Metcal at reasonable prices.

Fig. 13

Doing it Right

Both crimp and solder technologies are useful in the assembly and maintenance of your project. Each has unique requirements for selection of tools, materials and skill sets. It's a good idea to become familiar with the processes before you bring them to the airplane. The learning curves are steep for both technologies, so practice on some spare wires and components. ✢

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The tale of the scale reveals the truth.

Weighing your plane and calculating the center of gravity (CG) are critical steps to take before your first flight or after any major modification. Any aircraft will only fly well if its weight is distributed in such a way that its controls can easily produce stable flight. A CG that is too far forward will make the plane hard to land, and a rearward CG that is too far back can make the plane very unstable and possibly unable to recover from a stall. But before we get too far along, let's review a few key terms.

Weight

Empty weight: typically the weight of the complete airplane with vital fluids such as oil, hydraulic fluid, unusable fuel, and nothing else. This weight should include all interior items, wheelpants, and paint. If you weigh before painting, you should repeat the process after your plane comes out of the paint shop.

Gross weight: the maximum weight of the airplane, fuel, passengers, and cargo, as determined by the designer or the builder.

Useful load: the difference between gross weight and empty weight. However, the useful load may be limited by the location of various items in the plane due to their effect on center of gravity.

Datum

A point determined by the designer from which all other dimensions are taken. This may be an actual point such as the firewall or the leading edge of the wings, or it may be an imaginary point out in front of the airplane.

Arm or Moment Arm

The arm is the distance from the datum to the center of gravity of any object in the airplane that we need to consider. It is important because the farther any weight is from the datum, the more moment it will produce. This is similar to the principle of leverage. The longer the lever, the more force you can exert with it.

Moment

Moment is simply weight multiplied by distance. Intuitively you know that a large weight in the back of the plane (farther from the datum) will have more effect on the flight characteristics of the airplane than the same weight positioned near the center of the plane. We can calculate that effect by determining the moment that such a weight exerts.

Center of Gravity

The center of gravity, sometimes just called CG for short, is the imaginary point at which the plane could be balanced, as if all the weight of the plane were concentrated in a single point. You can calculate the center of gravity by dividing the total moment by the total weight for any given load. The relationship between the center of gravity and the center of lift plays a vital role in determining the stability of the aircraft. A pilot is expected to know these things from his or her training, but it is easy to forget.

What You Need

To weigh any aircraft you will need a good set of scales. Calibrated electronic scales are the best choice, but admittedly they are expensive. Sometimes an EAA chapter can buy a set and share it among the members. There are now bathroom scales that go up to 500 pounds, making that a lower-cost option, but the accuracy of these scales is far from assured. Weight and balance is important enough to be sure it is done well, so use the best scales you can get. Along with the scales, you will need some ramps to get the plane up on the scales, and a level place to work that is protected from the wind.

Besides good scales, good information is very important. Kits and even plans should have information about weight and balance measurements and the CG envelope. The better plans and assembly manuals have step-by-step guidance for weighing your plane and calculating the center of gravity. At a minimum you need the datum point and the CG envelope to do a proper weight and balance. Everything else can be weighed or measured, but without those two items you are really in the dark.

Measure First

Before weighing the plane you will need to verify the location of the datum and other key points. To do this you will

Dave Prizio

Dave Prizio is a Southern California native who has been plying the skies of the L.A. basin and beyond since 1973. Born into a family of builders, it was only natural that he would make his living as a contractor and spend his leisure time building airplanes. He has so far completed three—a GlaStar, a Glasair Sportsman, and a Texas Sport Cub—and he is helping a friend build a fourth, an RV-8. When he isn't building something, he likes to share his love of aviation with others by flying Young Eagles or volunteering as an EAA Technical Counselor. He is also a member of the EAA Homebuilt Aircraft Council.

Photos: Paul Dye

Use a plumb bob to drop a line down from the center of the spinner and from the center of the tail cone to establish a line from front to back on the floor.

Plumb down from the leading edge of the wings or whatever other reference point is needed to establish the datum location. Use the same basic technique to drop down the locations of the mainwheel and the tailwheel.

likely need a tape measure, a plumb bob, some masking tape, a pencil or marker of some sort, a carpenter's chalk box, and a level. A carpenter's square can also be helpful, but you can probably do without it if you need to. You will also need some boards of various thicknesses to level the plane and a support to elevate the tail if you are weighing a plane with conventional gear.

One might ask, "Why do we need to verify dimensions? I followed the instructions." You would be amazed to see the problems that come up. One plane we saw had some of its dimensions referenced to a firewall datum and others to a wing leading-edge datum—on the same plane. Measuring everything was the only way to sort this out. Another plane had trailing-link maingear that swung back as fuel was added. In that case, the maingear location had to be measured with no fuel, and with full fuel, to do the weight and balance calculations correctly. In another, the builder had modified the gear to move the maingear forward. Most of the time there are no problems with dimensions, but most of the time is not the same as all of the time. Measure and verify, then weigh.

Getting Started

The measuring process begins with finding a nice, flat, clean floor, preferably inside, out of the wind, and then leveling the plane. Then use a plumb bob to drop down marks for the center of the spinner and the center of the tail cone to the floor. It works well to put tape on the floor in the approximate location, and then make an exact mark on the tape. Next, establish a longitudinal line from front to back using a carpenter's chalk box. Establish the datum by dropping down another mark, from a point of known location such as the firewall, using the plumb bob again and mark it on the longitudinal line. If the leading edge of the wing is the datum, mark both wings and connect the two points with a line. Make a mark where that line crosses the front/back line. Do the same thing for the mainwheels and the tailwheel. It is usually necessary to offset from the tailwheel to clear the leveling support.

Now you can place your tape measure on the datum mark and measure to your key points. Compare these numbers to the plans or assembly instructions and double-check and adjust as necessary. You will need to use the actual measurements in your calculations, even if they don't agree with the plans or the manual. If there are any differences exceeding fractions of an inch, you should find out why before you go any further.

Line the plane up with some gentle ramps to make it easy to push the plane onto the scales. Weigh the plane inside a hangar if at all possible.

Be sure to zero out the scales before you start. Many scales allow you to zero out the weight of leveling boards or chocks at this time.

Center each wheel on its respective scale for best results.

Weighing the Plane

The plane should be weighed indoors, out of the wind. If you cannot weigh it indoors, you must do it when there is no wind. Any wind can upset the weight measurements, since wings are designed to produce lift. Position the scales and the ramps so you can push the plane up onto the scales. You will need some help to do this in most cases. Remember to be safe at all times. Discuss what you are going to do before you do it, and then coordinate your efforts. With a taildragger, you will need to move the tailwheel support as the mains roll up onto the scales. Chock the wheels once they are up on the scales if possible.

Now record the weights of each mainwheel and the nose- or tailwheel. The two mainwheels may have different weights. This is normal and should not be a concern, as long as the difference isn't too great. You will need to subtract the weight of any chocks or leveling boards placed on the scales. It is generally best to place leveling boards underneath the scales to avoid this problem.

There is always a debate over whether a plane should be weighed with no fuel or full fuel. I prefer to weigh with no fuel, and then take a second weight with full fuel, if time and circumstances allow. This makes it easy to verify the location of the fuel in the plane. Empty weight means with oil and other fluids at their normal levels, and no fuel except unusable fuel aboard. If you have done your fuel system testing (see KITPLANES®, December 2012), you already have an unusable fuel quantity to use. If not, then why not? Go test your fuel system. Others like to fill the tanks and, knowing how much fuel they put in, calculate the empty weight and moment by subtracting out the fuel. This works, but has some disadvantages, such as having your plane completely full of fuel for your first flight.

Do the Math

With your weights and fuel quantity duly recorded, it is time for a little math. No

The plane must be level to get accurate weights. With a taildragger this means elevating the tail. Use the prescribed points on the airplane to assure it is level.

The tail will need substantial support to get the plane level. It is best to place the tail scale on top of the support rather than underneath it.

groaning, please; this is not calculus. For those of you with some computer skills, this is a great time to create a little Excel spreadsheet. However, a calculator will do just fine. Make a little table with three columns—weights, arms, and moments. Enter the weights in the first column, one at a time. Then multiply each weight by the distance that point is from the datum based on your measurements. That is the arm. Finally, multiply each weight by its arm to get the moment for that weight. Then total the weights and the moments. Your total weight is your empty weight, or your empty weight plus fuel if you weighed it that way. If you weighed the plane with full fuel, you need to subtract that weight from the weight you measured to get your empty weight. You also need to multiply the fuel weight (pounds, not gallons) by the arm for the fuel tanks from the assembly manual or plans to calculate the fuel moment. Then subtract the fuel moment from the total moment you previously calculated. (See why we like to weigh the airplane without fuel? It means less math—and a smaller chance for error.)

You now have the empty weight and empty moment. From this you can calculate your center of gravity by dividing the moment by the weight. These calculations can be done in inches and pounds or centimeters and kilograms; it does not matter as long as you are consistent. Just remember to use the weight of fuel and not the quantity in gallons or liters for your calculations. The empty weight, CG, and moment numbers (shown in Table 1) now become the basis of all weight and balance calculations, so be sure to record them in your builder's log.

Testing Loads

Time for some more tables. The tables should include columns as before (weight, arm, moment) and rows for pilot weight, front passenger weight, rear passenger weights, cargo, and fuel. If you have more than one cargo area, each one must be included separately. Various load conditions need to be tested to make sure the plane will be safe to fly.

The first test is the forward CG test (Table 2). In this test the weight of the pilot and his or her moment are added to the empty weight, along with 30 minutes of cruise power fuel. The calculated CG must be behind the forward limit CG to pass this test. If not, you will need to add ballast to the tail until it does. If you have a forward cargo hold, you should also add weight to this area until you reach the forward

Owner Louise Hose records the weight of each wheel from the scales.

Table 1: Table of Actual Weights and Measured Arms

Point	Weight (pounds)	Arm (inches)	Moment (in-lbs)
Left Main	520	58.0	30,160
Right Main	532	58.0	30,856
Tail Wheel	69	238.0	16,422
Totals	1121 (empty weight)	69.08 CG*	77,438

**CG calculated by dividing total moment by total weight*

Table 2: Forward Limit Test

Item	Weight (pounds)	Arm (inches)	Moment (in-lbs)
Empty Aircraft	1121	69.08	77,438
Pilot	170	87.4	14,858
Passenger	0	87.4	0
Fuel	30 (5 gallons)	70.0	21,000
Baggage	0	117.0	0
Totals	1321<1600 OK	71.5>68.7 OK	94,396

Table 3: Aft Limit

Item	Weight (pounds)	Arm (inches)	Moment (in-lbs)
Empty Aircraft	1121	69.08	77,438
Pilot	170	87.4	14,858
Passenger	170	87.4	14,858
Fuel	89 (14.8 gallons)	70.0	6,230
Baggage	50	117.0	5,850
Totals	1600 = 1600 OK	74.5<76.8 OK	119,234

Table 4: Typical Load

Item	Weight (pounds)	Arm (inches)	Moment (in-lbs)
Empty Aircraft	1121	69.08	77,438
Pilot	170	87.4	14,858
Passenger	170	87.4	14,858
Fuel	139 (23.2 gallons)	70.0	9,730
Baggage	0	117.0	0
Totals	1600 = 1600 OK	73.05>68.7 OK 73.05<76.8 OK	116,884

Here is the typical load for a $100 hamburger flight. Note that full fuel load of 38 gallons cannot be carried with this combination of pilot and passenger.

CG and note the number. You may not be able to use the maximum allowable weight in the forward hold without having any weight in the rear.

Next is the aft CG test (Table 3). Include the pilot and maximum allowable cargo in the rear. If you are still forward of the aft limit, experiment with adding passengers and fuel in various locations, up to the maximum gross weight and rear CG limit. The critical load condition will vary from one model of plane to another. Your worst-case plausible loading will likely be with two people in front, maximum cargo in the rear, minimal fuel, and passengers in the rear seats to reach the gross weight limit.

It is good to also test the most likely loading conditions such as pilot and front seat passenger with full fuel and no cargo, or other loading scenarios based on your typical flying. If you ever get ramp checked, it is good to have these weight and balance calculations readily available.

Once you have completed all of these test calculations, you will need to put something together that you can keep in the plane as the official weight and balance. This is required for safe flight and to keep the FAA happy.

The forward most plausible loading scenario easily falls behind the forward CG limit of 68.7. Unless the aircraft is modified from its present configuration, it is difficult to imagine how one could load this plane too far forward. Of course, the actual weight of the pilot/owner should be used in these calculations.

Even though this is not a particularly likely load scenario, Table 3 shows the most rearward loading imaginable without exceeding the baggage limit of 50 pounds. With this aircraft, it is unlikely that any plausible load could exceed the aft limit of 76.8. As before, actual pilot and passenger weights should be used for your calculations.

Equipment List

Larger planes will have detailed equipment lists attached to the weight and balance information listing major components, especially any items that are removable such as radios. It is a good idea to do the same for smaller planes, too. At a minimum you should note what fluids are included in the empty weight, such as the quantity of oil and any unusable fuel. If your plane is one that is often fitted with larger tires and wheels, it is a good idea to note the tires and wheels you have installed, along with the weight, arm, and moment. If you go back and forth between floats and wheels, you will need two sets of weight and balance figures to cover both configurations.

Final Note–Gross Weight

Inevitably when a builder sees what his or her new plane weighs, there is a bit of disappointment that the empty weight didn't come out lower. That is to be expected. It is really easy to add weight to an airplane and really hard to keep it off. Disappointed or not, you should resist the temptation to simply bump up the gross weight to make up the difference. Dick VanGrunsven, for one, has come out very strongly against increasing gross weight of RV airplanes and for a good reason. The performance and structural integrity of the aircraft are based on the designer's gross weight. Adding to that weight decreases safety and performance. There is a margin of safety in all designs to be sure, but as VanGrunsven says, that margin belongs to the designer, not to you.

Keep your airplane light and as simple as possible (but no simpler). Weigh it carefully and pay attention to gross weight and CG limits. You will be safer and get better performance out of your plane if you do. ✢

Cutting aluminum on a table saw.

The first time I watched someone cut a one-inch thick slab of 7075 aluminum with a table saw, I thought, "You must be crazy!"

It turns out they were not crazy at all. The table saw, when equipped with the right blade, is an awesome tool for cutting aluminum. Add a sled with some basic hold-downs, and you can create parts that look like they were made on a milling machine.

My friend Richard Cunningham did just that. His design, "Lucky Dog," features an aluminum tube fuselage with abundant gusseting. With some clever fixturing and a basic sled system, he made all the gussets, attachment plates, and brackets using only a drill press, table saw, and disc sander. Since most of Richard's plane required several of each type bracket, he batch processed them by stacking the blanks for common drilling, sawing, and finally sanding the corners round.

Saws

Table saws come in many sizes and shapes. Portable benchtop saws like the kind sold at home improvement centers run from $200 to $600. Low-end portables are very noisy, not very sturdy, and they are not accurate enough for anything other than basic carpentry. At the high end of portables the saws are more solidly built and capable of reasonable accuracy. Portables don't pack the power

(Left) Richard Cunningham and "Lucky Dog". (Right) Examples of components made using the methods described.

Bob Hadley

Bob Hadley is the R&D manager for a California-based consumer products company. He holds a Sport Pilot certificate and owns the VW-powered Victory Stanley Fun-Kist.

(Left) Attaching the runners to the sled base. (Right) Clamping the fence square for screwing and gluing. The front block is a spacer for clamping and is not part of the sled.

of their stationary brothers, so that limits their usefulness for aluminum work. But if your project consists of brackets, plates, or gussets ⅜-inch thick or less, a good portable saw will do just fine.

Stationary saws start around $600 and go up (way up!). At the low end are so-called "contractor's" saws and at the high end you'll find classic "cabinet" saws like the Delta Unisaw. Even further up the scale are enormous saws with sliding tables for handling 4x8 plywood sheets; but for the purpose of this article and the type of parts typical for kit or plansbuilt aircraft, the cabinet saw would be tops.

Blades

Table saws come with 8- or 10-inch blades for woodworking. You must install a carbide-tipped blade designed for non-ferrous materials (aluminum, brass, etc.). You might have to go to a specialty tool store or an aluminum supplier to find a blade. If you're using a portable saw or a contractor's saw, get an 8-inch blade. Just like propellers, the smaller diameter helps compensate for lower power. A cabinet saw typically has three horsepower or more, so a 10-inch blade works fine. My personal favorite blade is the Alumi-Cut by Tenryu. Their 8-inch Alumi-Cut has 60 teeth and the 10-inch is available with 60, 80 or 100. The 100 tooth blade is more expensive (about $80 versus $70 and $50 respectively), but will give better cuts in thinner stock and still work fine for thicker material.

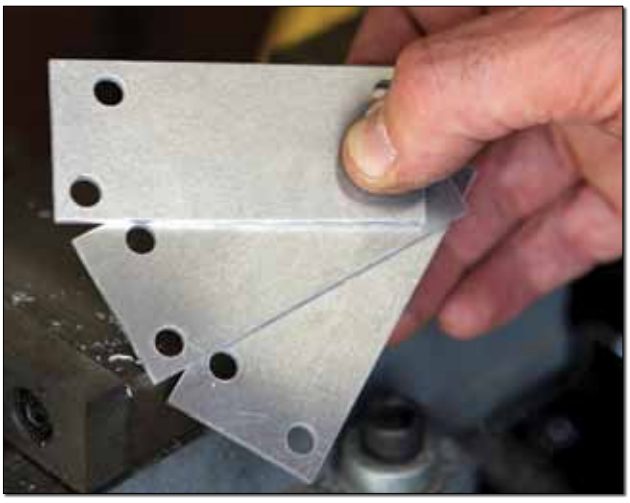
One thing about cutting aluminum on a table saw is it makes a lot of everything: noise, chips, and heat, in that order! So wear earplugs, safety goggles and, before you start, clean out the dust collection system of wood dust and chips. I use my regular dust collection system when cutting aluminum. It doesn't suck up all the chips, but it gets most of them and without it the shop would look like it was droned with a glitter bomb. Although aluminum chips coming off the blade probably aren't hot enough to ignite sawdust, why take the chance?

Material, Layout, and Prep

Good parts start with good material and layout. If your plans don't call out the type of aluminum, be sure to research your options. There are big differences in strength, corrosion resistance, and machinability across the spectrum of alloys that make up the aluminum family. The better machining aluminum alloys include 2011, 2024, 6061-T6/T651, and 7075. With a sharp blade and steady feed, any of those alloys cut cleanly. Avoid un-tempered alloys like 6061 T0 (basically anything that is not T6 or T651), as it will gum up and ruin your saw blade. 2024 and 7075 are the strongest. The best machining aluminum is 2011 and it is comparable to 6061 T6 in strength, but it gets a "D" for weldability and is three times the price. Why would anyone use it? There are many production settings where the faster machining time outweighs the higher price.

After the glue is dry, a test cut confirms the fence is square. (Right) A stop is clamped to the fence to create repeatable length parts.

Photos: Bob Hadley



(Left) Spot drilling before (Right) final drilling.

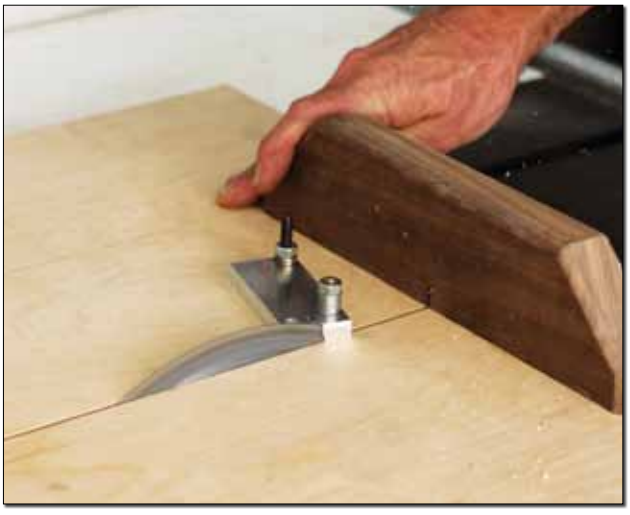
The key to this project is a sliding table saw accessory called a sled. Woodworkers will recognize the configuration as a cross-cutting sled: a plywood base, hardwood runners to fit the miter slots, and a fence. The fence serves two purposes: as a reference surface for squaring cuts and a convenient handle for advancing the sled into the blade. The base is made from ¾-inch Baltic birch plywood, the runners are sized to fit the table slots (usually ⅝ x ¾), and the fence is 1¾-inch hardwood that is square and straight. The fence must be positioned two or three inches from the trailing edge of the sled. When you make the initial cut into the sled, position the blade only as high as is necessary for the thickness of material you plan to cut, and then just enter the fence partially.

Making Parts

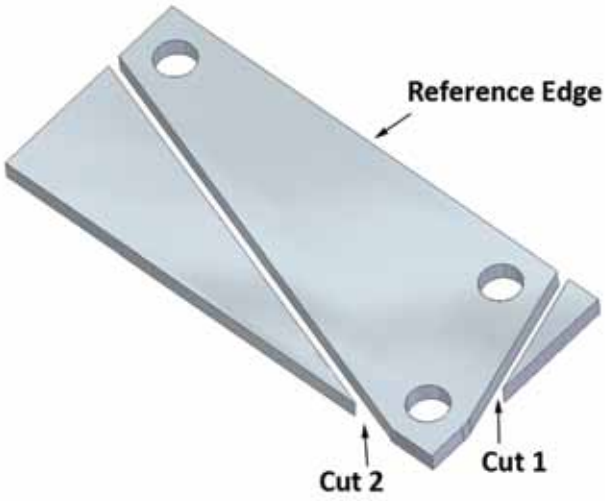
After ripping a strip of ⅛-inch thick 6061 T6 to width on the table saw, I used the fence to prepare three blanks of equal length. A simple plywood scrap was clamped to the fence to create a repeatable stop. With one blank marked to locate the holes and center-punched, I stacked and clamped them into the drill vise for "gang" drilling. I like to start by spot drilling. Spot drills are stubby rigid drills designed to provide a more precision "center" than you get with a center-punch. Twist drills may or may not be straight; so even if lined up on a center-punch mark, the hole you drill may not be square to the mark. Spot drilling or "spotting" the hole helps that problem. Another way to make precision holes is to "pre-drill" the hole slightly undersize and then finish it to size with an end mill (works only if the hole size is a standard end-mill size). It only works to spot, pre-drill, and then plunge-mill the hole to size if your blanks are secured in an anchored vise. You'll never hit the hole on center with an end mill unless you've clamped the part securely.

If your blanks are not equal or your vise less than great, one or more of the blanks might slip out of alignment as you drill. Combat this by adding a clamp, or bolt them together after drilling the first hole. It's more important the holes be perfectly aligned than the raw edges (which we'll saw off anyway).

Now comes the fun part: bolting the blanks to the sled and sawing. Last month I introduced the Vix bit for centering pilot holes. The parts need to be positioned



(Left) With the cut line on the sled kerf, the fixture holes are set with a Vix centering bit. (Right) First cut!

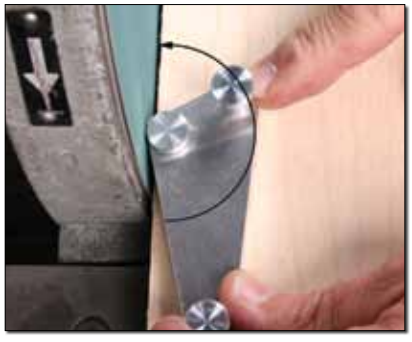


With a second setup and the parts secure, the second cut is made. Check out the companion video at *http://tinyurl.com/kp-tablesaw.*

so the cut line is right at the kerf edge on the sled. You will notice in the photos the parts are located on the sled some distance from the fence. Since none of the cuts are square to the fence, it plays no part in locating or holding. You can fixture the parts anywhere along the kerf. In fact, for small parts, the sled doesn't need to be any bigger than the width of the miter slots. But once you have a sled you will be using it for different jobs, so it's a good idea to make it a reasonable size to survive repeated uses. After a few years, if and when it has so many holes it looks like Swiss cheese, you can make another one. The hold-down bolts can be flat head or pan head screws or whatever works. You will have to countersink or counterbore the backside according to the hardware you have. This is the reason to use ¾-inch thick plywood: to have enough material to counterbore for the hardware.

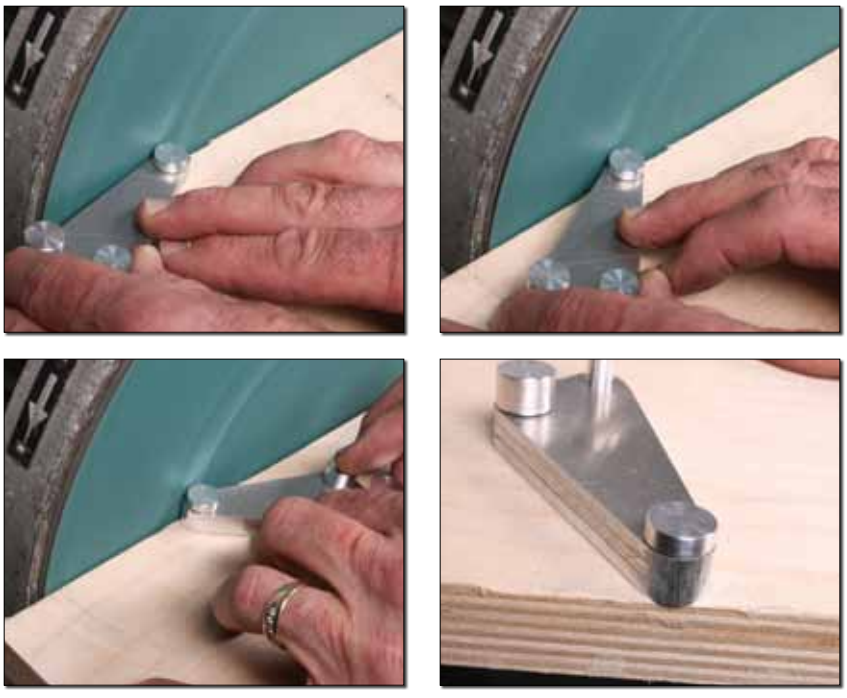
Two bolts are required to hold the parts down. If one is very close to the saw, be sure the nut or bolt head clears the blade. Use a spacer if needed to move the hardware clear of the spinning blade. The Alumi-Cut blade works great on aluminum, but if you collide with a steel screw or nut, it could damage the blade. Best to avoid that!

Check the alignment and cinch the parts up tight. Fire up the saw and, with even and steady pressure, feed the sled into the blade and make the cut. You can't go too slow at first. With a new blade, you probably won't feel any resistance so watch carefully for the parts to

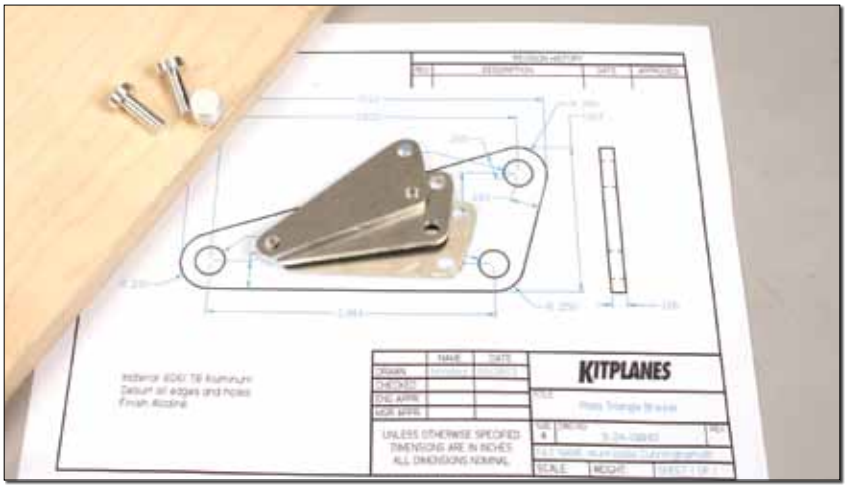


Rounding over corner number one: The center pin is pegged to the plywood sled, which has a runner attached to index it to the miter slot in the table. Pegs are inserted into the open holes to keep the three parts aligned and identical.

Rounding over corner number two: The pegs were turned on the lathe from scrap aluminum.



Rounding over corner number three.



With some simple tools and basic skills, we have three professionally made, but even more important, identical parts.

sever and back the sled back out. The process is the same for successive cuts: line up the cut line, position the anchors, tighten and cut. The demonstration part required two fixtured cuts. The third side was established with the sawing of the initial blanks, and the hole locations were referenced from that side.

Check out the video on the KITPLANES® web site *(http://tinyurl.com/kp-tablesaw)* that demonstrates the set-up and feed rate. It will give you an idea of what to expect.

With a second setup and the parts secure, the second cut is made. You can see this in the companion video, too.

You might ask, "Is it really necessary to do it this way?" Of course not! If you only need one of a particular bracket or gusset, a band saw and handwork on the disk sander will get you there. But if you have batches of identical parts to make, in the long run it's always better to set up a fixture. ⊣

Got a question for or job that needs some assistance from the Home Shop Machinist? Did you make or do something in your home shop that would be of interest to other builders? Send us a description of the part and where it's used. We'll consider it for a potential topic for a future HSM column. If we pick your request, be prepared to supply the raw material and, if it's part of a published plan, access to the original design drawings. Send inquiries via e-mail to editorial@kitplanes.com and put HMS in the subject line. Due to liability, certain items may be limited to the construction of a "demonstration" part for instructional use and display only.

Summary of tools used this month:

- Delta Unisaw
- Tenryu 10-Inch 100T Alumi-Cut Saw Blade
- 12-Inch Disk Sander with 120 Grit Sandpaper
- Micro-Mark Benchtop Milling Machine
- 3/8-Inch Spotting Drill
- 15/64-Inch Twist Drill
- 1/4-Inch 4-Flute End Mill
- #5 Vix Bit
- Hand Drill

Picking up the pieces.

"GA is essentially an airline or maintenance operation of one, which puts the responsibility for sound decision making on one person's shoulders."

—Deborah Hersman, Chair, NTSB

I know from personal experience: you will not have a premonition the day you have your aviation mishap. It's a shame, really, because it would be nice to know so you could clear your schedule in the weeks following to take care of the details that come after a mishap. And NTSB Chair Hersman's statement above is so true, heck, even more true in Experimental aviation. No one is going to do the work for you.

I've been there. In 2001 I experienced a total loss of aircraft and the paperwork aftermath that follows. It's a dunk into the aviation regulatory system that sticks with you. If you fly with the attitude that there are those who have had a mishap, and there are those who will, well, then you need to know what I'm talking about.

The FAR/AIM, known as "the bible" of the FAA, has some pretty clear delineators of what makes an aviation accident. An accident is defined as "an occurrence associated with the operation of an aircraft that takes place between the time any person boards the aircraft with the intention of flight and the time when all such persons have disembarked, and in which any person suffers death or serious injury, or in which the aircraft receives substantial damage." An incident is an occurrence other than an accident that affects or could affect the safety of operations. (See 49 CFR 830.) Federal regulations require operators to notify the NTSB immediately of aviation accidents and certain incidents.

So what kind of damage is "substantial"? In my case it was easy: the aircraft sunk after being ditched in the Atlantic Ocean. That's pretty substantial. For a friend of mine, who lost a wheel during a rough landing that caused his Sonex to nose over, it was a little more subtle. There was damage to a flight control (the rudder), and damage to flight controls is on the list of things that make an "incident" into an "accident" in 49 CFR 830.

A recent discussion on Van's Airforce.net brought up the question asking if an RV-10 door departing the aircraft on takeoff constitutes an accident. (There have been a few of these happenings.) Turns out that in this case it was just an incident, because the door was not considered structural and it departed cleanly. If it had hit the tail and damaged the rudder, well, the odds that the mishap would be called an "accident" rise precipitously. Other problems on the NTSB list include damage or failure that adversely affects the structural strength, performance, or flight characteristics of the aircraft, *and* that would normally require major repair or replacement of the affected component. The RV-10 pilot did a great job bringing the airplane back around in the pattern for a normal

Incident or accident? With the aircraft resting on the flaps, and the left aileron clearly on the ground, you can bet this one was an accident! (The damage to the landing gear, by itself, is not.)

Amy Laboda *has taught students how to fly in California, Texas, New York and Florida. She's towed gliders, flown ultralights, wrestled with aerobatics and even dabbled in skydiving. She holds an Airline Transport Pilot certificate, multi-engine and single-engine flight instructor ratings, as well as glider and rotorcraft (gyroplane) ratings. She also helped with the build of her Kitfox IV and RV-10.*

Photos: Amy Laboda, R.E. Butcher

landing. His door damage, though it looked pretty bad, was not considered major. He reported it to the NTSB on the advice of others; but after looking over the aircraft, the FAA wished him well and left him to figure out what happened and how to fix it.

So, what else is not an "accident" in the eyes of the NTSB? Engine failure or damage limited to an engine if only one engine fails or is damaged, bent fairings or cowling, dented skin, small punctured holes in the skin or fabric, ground damage to rotor or propeller blades, and damage to landing gear, wheels, tires, flaps, engine accessories, brakes, or wingtips are not considered "substantial damage" for the purpose of 49 CFR 830.

And, if it's not an accident you don't need to worry about the NTSB, right? Not quite. You see, serious "incidents" must also be reported (the reason why that RV-10 driver was wise to do so).

I know, your next question is, "What does the NTSB consider serious?" Any midair collision, inflight fire, flight-control system malfunction or failure in flight, required crewmember incapacitation in flight, or damage to property other than the aircraft in excess of $25,000 needs to be reported to the NTSB. It's quite a list, which is why 49 CFR 830 really should be required reading for anyone who operates an aircraft, and it should be specially reviewed by homebuilders in the test phases of flying. More accidents and incidents happen during the test phase immediately post-build than at any other time in an aircraft or its pilot's flying.

A safe landing on a dirt road during phase 1 testing with no damage? The FAA and NTSB said no harm, no foul.

Let's say you've had a problem during your aircraft's test flight that forced you to land on a road. Is it an accident? Well,

It would be hard to explain this as a "Q-Tip" designed prop. It probably would have a major affect on the performance of the aircraft, so a report to the NTSB would be justified.

if you hadn't hit the sign with your wing and crunched the aileron maybe not… but let's say you did, and a flight control was seriously damaged on the off-field landing. Who do you call?

Honestly? My first call after my ditching, once my brain stopped methodically counting my passengers and cheering that they were all with me, all of sound mind and body, was to my airplane insurance broker. He's a great guy, and if it weren't for him, I might have gotten into trouble with the NTSB. You see, he's the one who reminded me that I needed to contact the nearest NTSB regional office immediately to file a report over the phone. In fact he looked up the number for me. The NTSB investigator who answered was polite and took all the basic information, and then told me I'd have 10 days to fill out form 6120 (downloadable from *www.ntsb.gov* now) and send it to him. Yes, another one of my aircraft partners could have done this for me, since the NTSB does provide that an aircraft owner, not necessarily the pilot at the controls during the mishap, can make the call. That said, I'd have still had to make a statement, so might as well be me, since I was not incapacitated.

In fact once I was thinking clearly, I grabbed an Aviation Safety Reporting System (ASRS) form from my airline pilot husband's kit bag and filled it out (no aviation professional leaves home without them; and today they are also downloadable from *asrs.arc.nasa.gov*) before filling out the NTSB form. I made a copy for myself, tore off the identifying information, and sent it in. The ASRS collects anonymous information about aircraft incidents and accidents and, from the data, provides aviators with excellent scenario-based "there I was" lessons that are designed to prevent mishaps. It is voluntary, preserves the privacy of its participants, and is infinitely educational for all who participate in aviation. To incentivize people to participate in this great group confessional, the FAA is willing to give participants who can show they submitted a report a "get out of jail free" pass—but only if the problem that generated the ASRS report did not result in an "accident" per the NTSB definition. Ergo: no "get out of jail free" card for me.

No matter. It was valuable practice, because Form 6120 is much more detailed than the ASRS report, and took quite a bit of time to fill out. The narrative section of the form, however, is very similar, and I was able to use quite a bit from my ASRS form there. Also, both forms have to be filled out and turned in within 10 days of the accident (or in the ASRS case, incident). No procrastinating.

Frankly, Form 6120 was a dry run for the insurance company papers that came after. The aircraft's insurance forms were child's play compared to the homeowner's insurance loss forms, which had to be filled out and submitted to claim for damages to the contents of the aircraft's baggage compartment (we were heading out on a long trip). I simplified that process by purchasing "contents" insurance with my aircraft's policy from that point on.

A homebuilder may be interested in purchasing back the accident aircraft from his insurance company in the case of a total loss. That way he can repair the aircraft himself. Someone who has purchased an Experimental, but does not have an A&P certificate, will have to go either to an A&P or the original builder (if he holds the repairman's certificate for the aircraft) in order to have it repaired. Again, this is something that needs to be worked out with the insurance company, if so covered.

I never met the NTSB investigator who handled my case, though I spoke with him several times. He was polite and to the point. I did meet two FAA Safety Inspectors in a hangar, next to my excavated aircraft (a most depressing sight), about two weeks after my accident. They made the decision to send my broken crankshaft to the NTSB Lab at L'Enfant Plaza in Washington, DC, where, a year later, it was determined that wear and fretting from improperly torqued bolts caused a minuscule wobble that eventually made the bearings become oblong and catastrophically fail, snapping the crankshaft at the second journal. Even with oil analysis at every oil change, we never saw it coming. So it goes.

My hope is that you never experience your aviation mishap—but be a wise pilot, and gather the knowledge you'll need for the moment now. That's the best insurance I know. ✢

My adventures at AirVenture 2013.

The Experimental Aircraft Association's AirVenture 2013 highlighted the new and novel, with exciting developments in the air and on the ground.

Electricity in the Air

Mark Bierele demonstrated his eGull 2000 equipped with a Zero Motorcycles 54-horsepower, dual-stator unit, identical to those powering three motorcycles up Pikes Peak a few months earlier. Flying in the ultralight area on Friday morning, he demonstrated takeoff runs under 100 feet, climbed steeply, and reached pattern altitude by the end of a short runway. Large flaps on the eGull allowed extremely short landings, with Bierele making turnarounds by mid field.

Bierele reports continuing to work with JoeBen Bevirt and his line of electric motors, so he might show up next year with a range of possibilities for powering his aircraft. Martin Koxxy, a Beaverton, Oregon homebuilder, is working on the wings for his eGull at this time and awaiting delivery of his Zero power package. We'll be following up.

Yuneec International, now identified as Greenwing International, had two complete e-Spyders on display and in the air, with one sometimes in the Innovation Pavillion with a partially completed fuselage. Two flew together down the main runway on Thursday, August 1, the first electric formation flight at Oshkosh.

"Celebrity test pilot," aviation writer James Lawrence, made his first electric aircraft flight Friday morning and demonstrated the e-Spyder's excellent performance as he and Bierele took turns flying the pattern. Although the airplanes both meet ultralight weight requirements, the eGull's 54 horsepower, compared to the e-Spyder's 32, gave it a better climb. Both aircraft were far quieter than other ultralights, especially those with raucous two-stroke engines. Their quiet passage overhead was noteworthy for a lack of even propeller noise, showing good propulsion design.

Announcers lauded this quiet flight, and wished they had such an airplane. Perhaps many in the crowd felt the same way as they departed the show. Both Bierele and Greenwing are making their kit aircraft available at around the same $40,000 price range.

We missed seeing Randall Fishman with his ElectraFlyer ULS and Dale Kramer with his electric Lazair amphibian. Both have made contributions to progress in this new realm of powered flight. Maybe next year.

Mark Bierele answers questions from the ever-present crowd. His flying displays helped impress announcers and attendees.

Greenwing's e-Spyder was a popular draw. The aircraft meets ultralight weight requirements and is powered by a 32-hp motor.

Dean Sigler

A technical writer for 30 years, Dean has a liberal arts background and a master's degree in education. He writes the CAFE Foundation blog and has spoken at the last four Electric Aircraft Symposia and at three Experimental Soaring Association workshops. Part of the Perlan Project, he is a private pilot, and hopes to get a sailplane rating soon.

Greg Cole of Windward Performance, Michael Lam, and Len Fox, test pilot on the Lam Aileron project. Airplane flew to Oshkosh from Bend, Oregon.

CAFE Foundation Challenges EAA'ers

Beyond repeated demonstrations of practical reality in the ultralight area, seekers could find a promising future in the Innovation Pavilion, a showcase of emerging technology, some of which is now available, unlike many "breakthroughs" perpetually five to 10 years away from commercial reality.

Dr. Brien Seeley, president of the CAFE Foundation, gave two talks Friday morning: one in the Innovation Pavilion and a second in the Rotax Pavilion a good walk away. Between the two he examined the problems faced by general aviation today, and gave some surprising answers.

Personal airplanes are expensive, with fuel, operation, hangar, insurance, and maintenance costs requiring a highly motivated owner. Airline travel wastes time with the lost productivity and annoyance of waiting in long TSA lines and being subjected to invasions of one's privacy.

Seeley's solution, developed in concert with NASA's Mark Moore, would provide safe, on-demand transportation within walking distance of your home, with door-to-door times beating those of automobiles, airlines, and even personal jets, while being quiet, affordable, and sustainable. Pocket airports no bigger than football stadiums, spread throughout urban and suburban neighborhoods, would host fleets of "Sky Taxis," efficient two-seat electric aircraft that would fly their passengers autonomously.

Seeley and Moore's Sky Taxis would be four times faster than cars and two times faster than a Learjet on a point-to-point basis. Without pushing the boundaries of easily achievable performance with current technology, they could take users at 120 mph on "your very own wormhole through the sky." Such "bizjets for the masses" would avoid TSA frisks and let you off at or within walking distance of your destination—much more convenient than the hours-long battle to get to or from (and through) large or small airports.

CAFE plans a series of challenges, similar to the very successful Green Flight Challenge, which will encourage competitors to use wheel motors to shorten takeoff and landing runs, quiet propellers to make small aircraft good neighbors, and a range of other technologies that would lead to the neighborhood-friendly airplane and accompanying pocket airports. Dr. Seeley thinks EAA members could win these challenges.

Dr. Seeley would make every adult a pilot, setting his or her own destination and being taken there with greater precision and safety than possible today. This would significantly expand the flying base from the 590,000 licensed pilots (lower than the number of doctors, according to my checkride overseer) now able to enjoy the freedom of the skies.

Innovative Aerodynamics

Several vendors displayed designs to eliminate runways altogether, or to improve the performance and economy of existing airplanes. If Dr. Seeley's vision is to become reality, airplanes will need to achieve more with less—as shown at AirVenture.

The Lam Aileron is an outgrowth of the roll control system the late Larry Lam developed through the 1980s. Applied to his little Wanderer, a low-wing, two-seat homebuilt, Lam claimed it not only eliminated adverse yaw, but helped make the airplane fly faster and land slower than it would have if equipped with more conventional controls.

Larry's son Michael, working with Greg Cole of Windward Performance, added this system to a Cessna Corvallis in Cole's Bend, Oregon workshop over the past few years. They flew the converted airplane to

Complex linkages of the Lam Aileron™ are apparent in this view.

Photos: Dean Sigler

JoeBen Bevirt of Joby Aviation and Joby Motors, among other enterprises, was on hand to answer questions from a constant flow of visitors.

Joseph Hutterer's different hybrid in climb, with jet engine down for added thrust, pusher propeller for cruise.

Oshkosh, where it was parked opposite the Aviat CNG demonstrator at the Innovation Pavilion's entrance.

Michael patiently explained the operation of the aileron's up-only operation ("Not spoilers," he kept insisting) and the Fowler-flap below. Because the Lam system allows the flaps to be lengthened to include the portion of the trailing edge that would normally be occupied by just the ailerons, the flaps are more effective, improving the maximum lift coefficient of the wing. This makes it possible to use a smaller wing, which reduces wetted area and increases speed. Compared to a stock Corvallis, Lam says the modified Corvallis has a lower stall speed, higher cruise speed, better rate of climb, and superior handling characteristics. They also claim a fuel savings of 20–30%.

Caren Sandusky of Reboot Technology had a display on her Mockingbird VTOL craft, a swing-wing, variable-geometry vehicle that looked a bit like something from *Avatar*. Its turbine propulsion would lift and motivate the craft through multi-blade fans similar to Caren's patented ceiling air-conditioning fans, high-efficiency units with blades similar to biplane wings.

JoeBen Bevirt's display, taking up a large corner at the Pavilion entrance, had astonishingly inventive approaches to several problems. Bevirt's motors power Dale Kramer's Lazair amphibian and will soon be tested on Mark Bierele's eGull.

Alex Stoll, an aeronautical engineer with Joby Aviation, explained several images of a bird-like creation on which differential thrust from cleverly concealed rotors at the wingtips and on the vertical stabilizer provide propulsion and control. A hybrid version could take two passengers up to 700 miles at 200 mph. Alex is currently test flying a "mule" that has all the utility, but little of the beauty, of the planned vehicle.

Different Powers

Next to Joby's display, Joseph Hutterer, a veteran aeronautical engineer with 42 years in the industry, showed his hybrid aircraft, a unique approach to improving the performance, safety, and economy of light twin aircraft.

Instead of mounting one engine on each wing, Hutterer has a single large turboprop on his aircraft's tail for long-range cruising. A small, retractable jet turbine on the nose of the craft drops down to add thrust during takeoff and climb, then retracts at altitude. This patented design eliminates light-twin asymmetric handling problems and lowers fuel use and noise.

Tomas Brøedreskift was on hand from Norway to show a model of his P2 Equator hybrid amphibian, covered in an earlier KITPLANES® article. It is a hybrid, with a reversible-thrust electric motor mounted on its high tail, much like a Seawind. Its roomy cabin and simplified flight and power controls should make it a favorite with future owners.

Getting the Lead Out

Both Swift Fuels and Aviat presented alternatives to the dwindling supply of 100-octane low-lead aviation gasoline.

Swift notes their proprietary processes synthesize petroleum or bio-fuel sources into an unleaded fuel meeting strict ASTM D7719 standards that can be used as an economical "drop-in" substitute for 100LL. As icing on the cake, extended engine TBOs and up to seven-percent improved fuel economy point to lower overall operating costs. Swift fuel also claims lower emissions and health issues.

In another approach to cleaner and more economical fuel burns, Aviat

Joby Aviation's two-seat, personal air vehicle, capable of 700 miles range at 200 mph in hybrid form.

Tomas Broedreskift came from Norway to show his hybrid amphibian.

This Aviat Husky has a dual fuel system that allows the aircraft to use either compressed natural gas (CNG) or avgas.

showed an A1-C Husky with a large bulge under the pilots' seats, a compressed natural gas (CNG) container that makes the Aviat the "first dual fuel, piston powered aircraft to operate on both compressed natural gas (CNG) and aviation gasoline." It could probably even fly on Swift's no-lead. The airplane is stock except for its Lycoming's 10:1 compression ratio to accommodate CNG combustion.

Aviat flew the dual-fuel machine more than 1000 miles from its Afton, Wyoming headquarters to park it outside the Innovation Pavilion. CNG, well known to truckers seeking refuge from high diesel prices, is also up to 80-percent cheaper than avgas. Less than $10 per hour in fuel costs should appeal to flight schools and other operators.

Where Swift's no-lead can use the normal distribution networks for other liquid fuels, Aviat claims their bird can be fueled anywhere there's a natural gas line. Regardless, the Husky's seven-hour endurance should enable returning home to a waiting CNG supply if necessary.

Where are the Other Electrics?

Sonex had its electric Waiex on display, but never any representatives in view when I visited. It would be great to see them continue in their efforts, especially since their e-Flight Initiative was an early front-runner in the alternative energies realm.

Akoya brought a lovely display to the French enclave at Oshkosh, but no airplane. They've dropped further development of their electric and solar plans for now.

What I Got Out of It

Electric aircraft are ebbing and flowing, with personal dedication and the current fortunes of many individual builders determining what flies and what continues in hoped-for development. We're still waiting for those great batteries and FAA approval for airplanes that are already here. I think we'll see progress when LSA rules change to allow electric powerplants.

In the meantime, new aerodynamics and new fuel systems might show a cleaner, greener side to personal flight, and again, dedicated individuals will make all the difference. +

RESOURCES

Aviat AC-1 Compressed Natural Gas Husky
www.aviataircraft.com/cng/

Greenwing International e-Spyder
http://greenwing.aero/

Hutterer Hybrid
www.huttererengineering.com

Lam Aileron
http://lamaviation.com/advanced-aileron

Sonex and the e-Flight Initiative
www.sonexaircraft.com/research/e-flight

Pipistrel's outdoor display showed present and future models, including the Panthera, their three-mode flyer (gasoline, hybrid, pure electric).

John McGinnis and family were on hand to discuss the future for his futuristic Synergy high-performance lightplane. Mosaic was created using a program called Mosaic and gleaned from 4,000 images.

Ask the DAR

Deregistration, operating limitations, amateur status, and finding a DAR.

BY MEL ASBERRY

Question: I have a question about the Jabiru donor who deregistered his airplane to avoid builder's liability and donated it to a non-profit organization. Can this plane be re-registered with a new number?

Answer: Once an Experimental/Amateur-Built aircraft is certificated, the builder can never be changed. If he has turned in the airworthiness certificate, as far as the FAA is concerned, it is no longer an airplane. The only possible category that might be used is Experimental Exhibition. This would be a "sticky" issue and most DARs that I know wouldn't touch it. It would certainly not meet the intent of the rules.

Question: I know this question has been asked before, but my A&P/IA insists that if you are not the original builder of an Experimental aircraft, it is illegal to perform any maintenance on that aircraft. My understanding is that the owner, whether or not they built the aircraft, may perform any maintenance that an A&P can perform except the condition inspection. What is the correct interpretation?

Answer: Your A&P/IA is misinformed. What he is thinking of is the requirement of who can maintain an aircraft contained in FAR Part 43. However, Part 43 does not apply to Experimental/Amateur-Built aircraft. Therefore, there is no regulation as to who can perform maintenance. Anyone can perform maintenance on an Experimental/Amateur-Built aircraft. It doesn't even have to be the owner.

Only the original builder, if he holds the repairman certificate for that aircraft, or an A&P mechanic can perform the condition inspection.

Question: How do you amend operating limitations?

Answer: Operating limitations may be amended by an aviation safety inspector from the local FSDO or a DAR with function code 33, plus the function code that pertains to the aircraft to be amended. For Amateur-Built, that would be FC 46.

Operating limitations are commonly amended to change the flight test location or to bring the op lims up to the current standards.

Question: I have the idea in the back of my head that I would like to build a plane when I retire. Hopefully that will occur next year, but after reading your last article, I am wondering if I will have a problem. You stated that 51% of the project must be performed by an amateur. I am a licensed A&P. Does that preclude my being considered as an amateur when building my plane? In case you are wondering, I would like to build a Velocity V-Twin.

Answer: No, your A&P certificate does not disqualify your "amateur" status for building an aircraft. If you were building the aircraft for someone else for compensation, or if you were building for the purpose of selling the aircraft, then it would be a problem. Building for your own education and recreation is totally acceptable as "amateur-built" status. Good luck with the V-Twin. That's a very interesting airplane.

Question: Does your DAR have to be local?

Answer: No. It is the intention that the aircraft be inspected by a local inspector, but it is not mandatory. Often a builder will request a known DAR from another region because of his expertise or experience with a particular type of aircraft. ✚

Please send your questions for DAR Asberry to editorial@kitplanes.com with "Ask the DAR" in the subject line.

Photo: Mel Asberry

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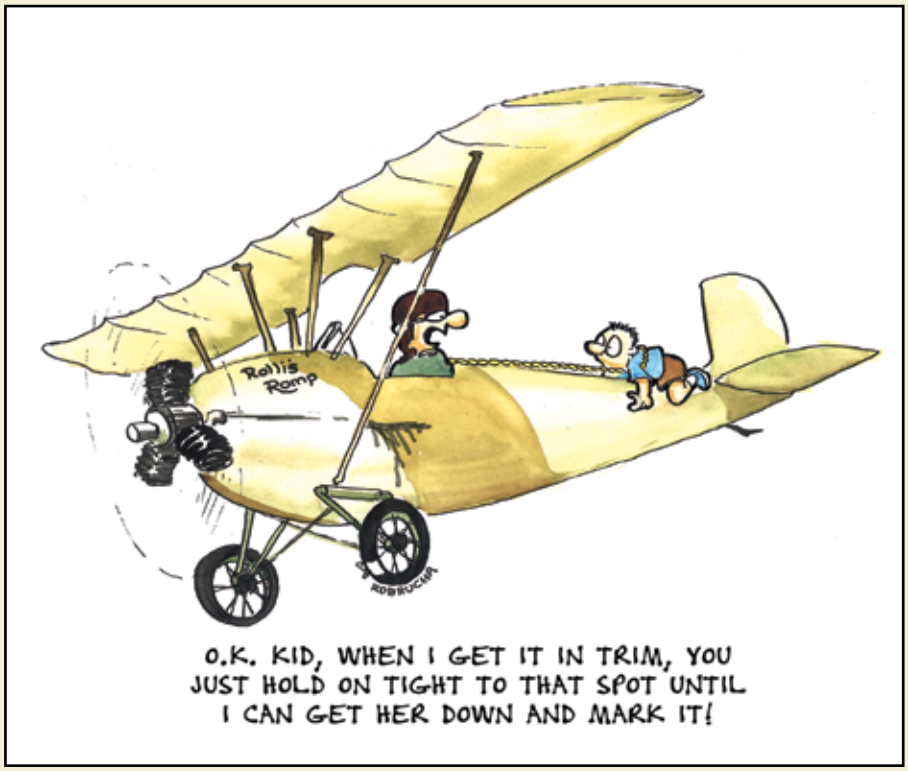

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Finding design help.

This month we consider a subject that is not strictly technical. Many homebuilders want to create an original design but lack the engineering know-how in some areas to do the design properly. They wisely seek the help of people who are more familiar with the particular technical area in which they are having problems. Unfortunately, getting technically qualified help when designing a new homebuilt airplane is not easy. Finding the right person to help make your dream airplane a reality is a quest that frustrates many would-be designers.

For example, some time ago, a reader wrote the following in a letter to me:

"I've been trying to design my own canard type aircraft and every time I've tried to get some advice and help, I'm told that my idea won't work and I should abandon it. I think it will work! How do I get someone to listen and help?"

There is no single magic way to solve this problem. I offer some general advice based on my experience and how I personally react when I am approached by someone with an idea. I hope it proves helpful.

Finding Help

Getting help on a project, particularly competent technical help, is not easy. You are asking someone to invest a significant amount of time and effort in a project that is not their own. To do this, you need to either get them interested enough in the project to work on the airplane for its own sake, or make it financially worthwhile for them to help you. The more unorthodox your concept is, the harder it will be to get people to listen. A few possibilities to explore when seeking assistance are:

1) Universities

Engineering colleges are very often looking for student research projects. If you can get one of the faculty interested in your concept, he or she may be able to get you together with an interested student. This can lead to the student doing either analysis or testing to fulfill his course requirements, and you getting free—or at least low-cost—data.

In recent years, many engineering schools have started programs where students build and fly UAVs (Unmanned Air Vehicles). You may be able to get them interested in flight testing a concept as an exercise in UAV development.

2) EAA Chapters

If you are not already a member of the Experimental Aircraft Association, join EAA and start attending meetings of your local chapter. You may be able to find someone who is willing and able to help. If no one in your local chapter is available, you might try other nearby chapters. The more contacts you make, the more likely you are to find the right help.

3) Paid Consultants

There are qualified engineers who are willing to work on almost anything on a pay-as-you-go consulting basis. The basic problem, of course, is that they cost quite a bit per hour. If you are lucky, you may be able to interest one sufficiently in the airplane to get him to reduce his rates. Some consultants advertise in homebuilder-oriented

If you're going to go radical, some professional help might be appropriate. New configurations require lots of analysis to get things right.

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

Photos: John Sbiegay

magazines such as KITPLANES® and *Sport Aviation*, and on the Internet.

Paid consultants should be approached with great caution. The qualifications of the people offering their services, particularly online, vary greatly. A slick web site with lots of pretty computer-generated graphics is not evidence of real technical qualifications. It is wise to find out what real, flying aircraft the consultant has worked on, and exactly what their part in its design was, before proceeding further.

4) Advertise for help

A classified ad in a general aviation oriented magazine may help get you and some qualified helper together. Several homebuilt and aviation-oriented Internet sites also provide a forum for people to seek advice or offer consulting services. The disadvantage of this approach is that you may also attract some people who are not qualified to help and will waste your time. As we discussed a few months ago in Wind Tunnel, there are a lot of people out there who offer authoritative-sounding advice, but lack the real knowledge to back it up.

Prepare Yourself First

Many of the letters I have received over the years seeking help contained nothing more than a very crude pencil sketch of an idea, and a general request to help. This kind of initial contact is not at all persuasive. It shows that you know very little about what you are trying to do, and have not invested much of your own time and effort into your idea.

In addition to aerodynamic concerns, this aircraft project might need some mechanical engineering help to evaluate the long driveshaft.

An approach like this is doomed to fail with most people. The only positive responses will likely come from paid consultants who will quote prices based on the idea that you will be hiring them to do essentially a complete design that looks something like your sketch.

Credibility is vital when you are asking someone to donate his time and effort to your project. They must feel that it is a worthwhile undertaking. If you are the person "designing" the airplane, you must take the time to learn at least the basics of airplane design on your own before seeking help on the project. No one wants to do the majority of the work on a project while under the direction of a "designer" with a vision, but no real knowledge.

Are the rudders large enough to compensate for the larger fuselage forward of the CG? How much drag can be expected from that fuselage behind the wing? These questions are complex, and an experienced designer might be able to supply answers.

A first step to take before seeking technical help on the final design is to do some experiments to show the merits of your concept. If you demonstrate that it can work, or at least that it has a reasonable chance of working, people will be more inclined to listen to you and maybe even help.

A good way to start off is to build a flying model. You can begin with a profile balsa or foam glider to get some very basic information on stability, and where the center of gravity should be. A moderately large radio-controlled model is the next step. Pictures or video of the model flying will go a long way towards convincing people that your configuration has some merit, and you will learn a lot in the process of building and flying the model that will help in the design of the full-scale airplane.

When you are talking to a potential helper, what you say during the conversation can be very important. First of all, have specific questions to ask, if at all possible. Remember that what you are asking may mean a lot of work. You want to get the person interested enough in your airplane to help you. If helping appears to be a lifetime task, the person will probably decline.

A general "What do you think?" type of question does not give any idea of what you are after and may put the person off. The same goes for a general "help me" appeal or a blanket declaration that

you have the "ultimate airplane." If your approach is well thought-out, and gives the impression that you have a reasonable understanding of what is involved in the project, a person is much more likely to listen to you and become interested in the project than if you sound like you don't know what you are doing. Any analysis or experimental data you have will also be useful in generating interest. Pictures or videos of a flying model of the configuration are particularly effective since they show that the thing will really fly and that you are serious enough about the project to have put in a lot of your own effort.

Finally, you must approach a conversation with an open mind and try to get as much information from it as possible. If someone says, "It won't work!," don't get angry; ask why they think that it won't work. You may be able to address the objection, continue the conversation, and convince the person that you have a good idea. If you get annoyed, the conversation is over. You should also listen closely to the technical points that are brought up, even if they are not what you want to hear. If the person you are talking to is professionally qualified, they may be telling you something important that will help you fix a problem and make your airplane a success.

When you do finally connect with someone who is willing to give technical assistance, be careful. Try to find out what the person's technical qualifications are. There are plenty of self-proclaimed experts out there and airplane design is not a place for the ignorant. Remember, these things can bite, and a radical, unconventional airplane is harder to design and make safe to fly than a conventional airplane. Make sure the advice you are getting is coming from a person who knows what they are doing.

Persistence is most important. Developing a new airplane configuration is not easy, and even after you have it working, many people will refuse to believe it. John Dyke was assured by several people that his Dyke Delta design would not fly...after he had over 500 hours on the airplane. Keep trying and, sooner or later, you will find the right help or learn enough to do it yourself. Good luck and be careful. +

Flying the pattern.

Over the past few months, we've discussed a lot about antennas, what to make them out of, how long they should be, and other important design factors. Now we come to where the copper meets the ionosphere.

All we've been able to say so far is that we can tell how much of the transmitter power (or receiver signal) is absorbed by the antenna and how much has been reflected back to the power source.

Now comes the real test—how much of that power is really being transmitted or received, and in what direction. Perhaps it is now time to introduce a concept that is practically impossible, but is a nice theory to measure our antenna against. We call this concept an "isotropic radiator." An isotropic radiator transmits or receives from all directions equally well—and is impossible to make. Think of a transmitter sitting in the middle of a copper basketball; the "pattern" of the radiation of that basketball is equal in all directions: left, right, forward, back, up, and down. It is a truly spherical pattern. Practical antennas can't do that.

A horizontal dipole antenna being installed in the wing of a composite aircraft.

The Truth

And here I will make a claim that may save you a few bucks in buying antennas: *Antennas cannot make power.* If somebody tells you they have an antenna that increases your transmit or receive range "all around," then run—do not walk away. Antennas pretty much work like a nozzle on the end of your hose. There is only so much water pressure and volume that you can have. You can have a round sprinkler that distributes that water over a relatively large area with each point of the water compass getting an equal amount, or you can have a nozzle that squirts that water in one direction at the expense of all other directions.

In the amateur radio "ham" world, we call antennas that squirt power at one point "beam" antennas, just like the beam of a flashlight. All the power (light) goes in the direction of where we point the antenna (flashlight). TV and FM radio stations have a far *different* problem, but approach it in the same way. Here the broadcast stations want to have their signals heard a maximum distance, but don't care about transmitting up or down. We have design ways of taking that signal and squishing it top and bottom, so that the radiation pattern looks a lot like an LP vinyl record (remember those?). Here, all of the signal is being squirted at the horizon and very little goes up or down. Working a satellite takes both of these techniques and forms a pencil beam that is pointed at one precise spot in the sky.

The problem, of course, is that the techniques for doing this make the antennas

Jim Weir

is the chief avioniker at RST Engineering. He answers avionics questions in the Maintenance Bay forum at www.pilotsofamerica.com. His wife, Cyndi Weir, was his high school sweetheart 50 years ago and now she keeps Jim from making stupid blunders in spelling and grammar. Check out www.rst-engr.com/kitplanes for previous articles and supplements.

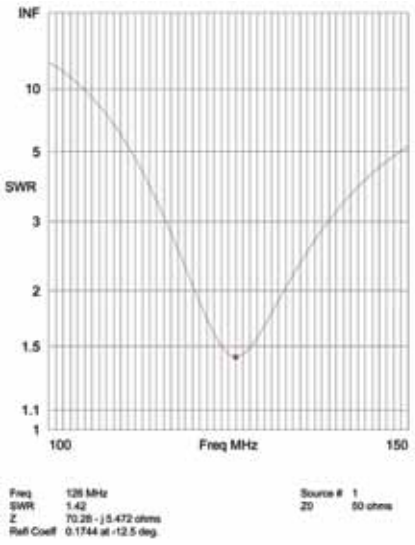


Figure 1. This VSWR plot shows the "goodness" of the dipole antenna over the frequency range.

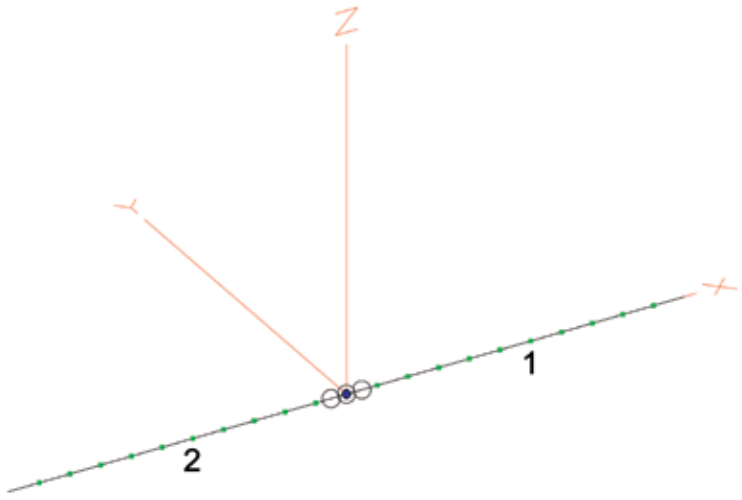


Figure 2. In this dipole antenna schematic, the aircraft's nose is on the Y axis, and the wingtips are on the X axis.

very large compared to, say, the Romex Ranger ground plane we designed a few months ago. You could probably fit the Ranger (or a variant) onto your airframe, but hoisting an FM broadcast antenna onto your plane might possibly be done if you are building a C-5 Galaxy.

What We Can Do

What does that leave us? Simple dipole "rabbit ears" and whip "spike" antennas. So, what does the radiation pattern of a dipole look like and where might we use it? Considering that aviation band nav signals have their signals horizontally polarized (they vibrate horizontally with respect to the earth's surface), we need a set of rabbit ears whose ears are laid out horizontally. Such an antenna, with elements roughly a quarter of a wavelength long, is the best we are going to be able to do. I'm sure by now you are tired of seeing the old VSWR curve showing the "goodness" of this dipole over frequency (Figure 1). What you have *not* seen to date is what the antenna looks like schematically as a plain old dipole (Figure 2).

At this time, let's take a further look at the antenna schematic drawing. The airplane is represented by those little circles in the center of the antenna. The X axis is what we call the lateral axis of an aircraft, the Y axis is the longitudinal axis, and the Z axis is the vertical axis. If you want to relate it to an aircraft in flight, the aircraft is flying to Y with the wings pointing on X and climbing or descending on the Z.

How does this antenna radiate? In some directions, excellent. In others, not so much. In Figure 3, the airplane

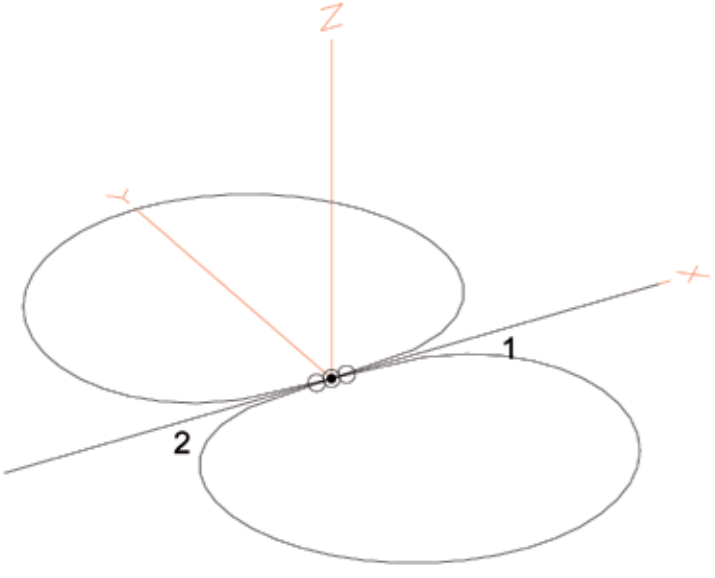


Figure 3. A three-view representation of how there is very little antenna response directly off of the wingtips with the dipole antenna.

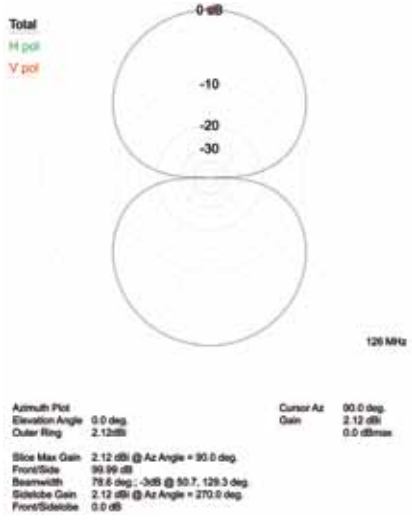


Figure 4. This antenna response plot shows that there is almost zero reception off of the wingtips (to the right and left of the figure). The data block at the bottom shows the gain or loss (in dBi) relative to an isotropic antenna.

Drawings and photos: Jim Weir

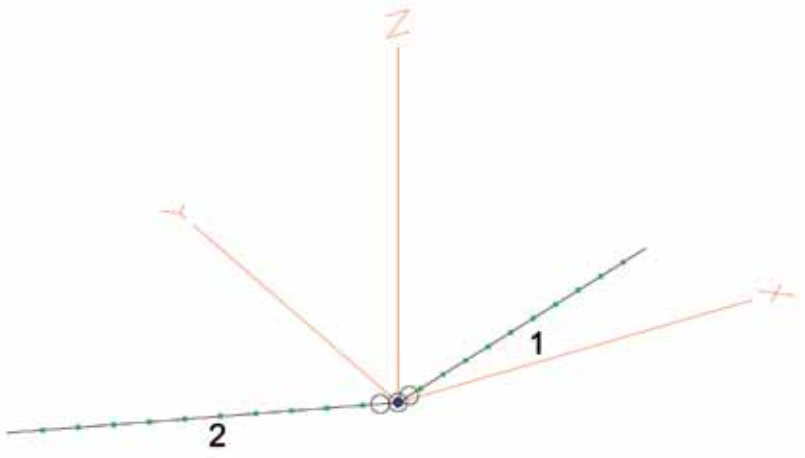


Figure 5. If we angle the dipole antenna elements slightly, we can fill in some of the coverage off of the wingtips.

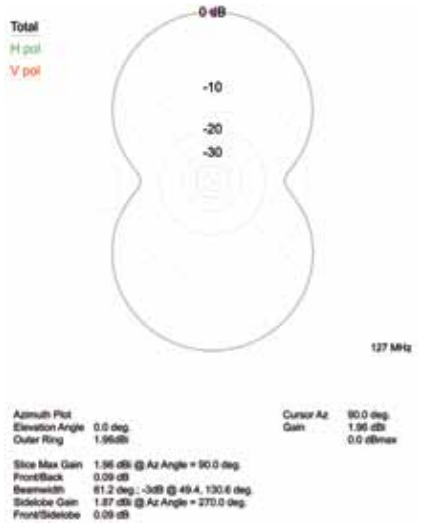


Figure 6. Angling the antenna slightly provides some coverage off the wingtips—at the expense of strength off the nose and tail.

is in the center of those dotted circles and the nose is along the Y axis. The antenna response is shown by the black circles; and we can see that, fore and aft, it is a pretty good antenna, but a station off the wingtips has almost zero reception.

Just to prove a point I made earlier, look at the radiation pattern from the top (Figure 4). The data line at the bottom "outer ring" shows the antenna gain or loss in dBi (decibels relative to an isotropic source)—a way of measuring power gain and loss.

Putting a slight angle onto the dipole elements (Figure 5) fills in the null off the wingtips with a slight reduction in the fore/aft gain, but allows reduced reception (Figure 6) to the sides of the aircraft (Figure 7). Experimentation shows that an angle between each of the elements and the X axis of 20° to 40° is a good compromise for dipole antennas. You will also find that the dipole with the V angle has *slightly* better reception in the apex of the V, and is generally pointed forward.

Real Antennas—Real World

So what is the pattern for our good old vertically polarized Romex Ranger (and by extension, whip antennas on metal aircraft)? The schematic (Figure 8) shows the radiation pattern in a horizontal direction to be nearly perfectly circular, but the horizontal pattern shows huge nulls top and bottom. But this is OK, especially for a ground station. Rarely do you want to talk to a station directly over you (and I do mean *directly!*). One or two degrees the other side of direct will

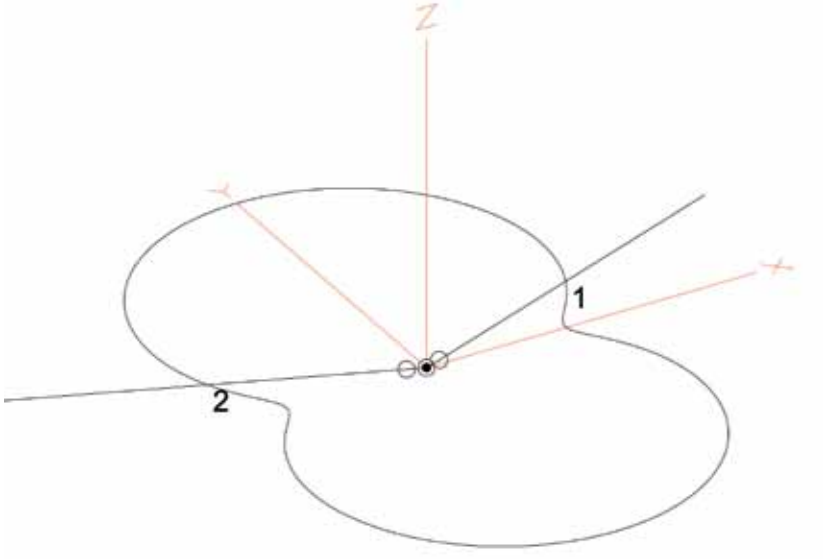


Figure 7. The effects of angling the elements is apparent in this three-dimensional plot—increased lateral coverage at the expense of fore/aft signal strength.

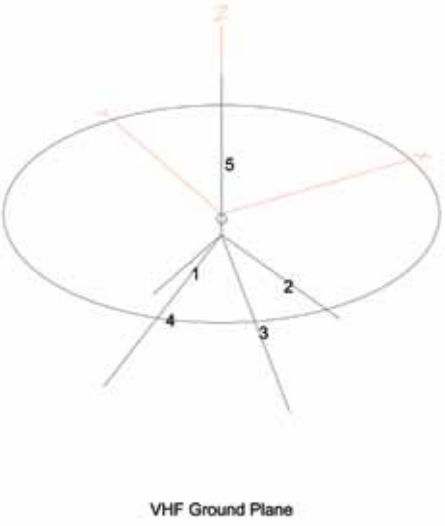
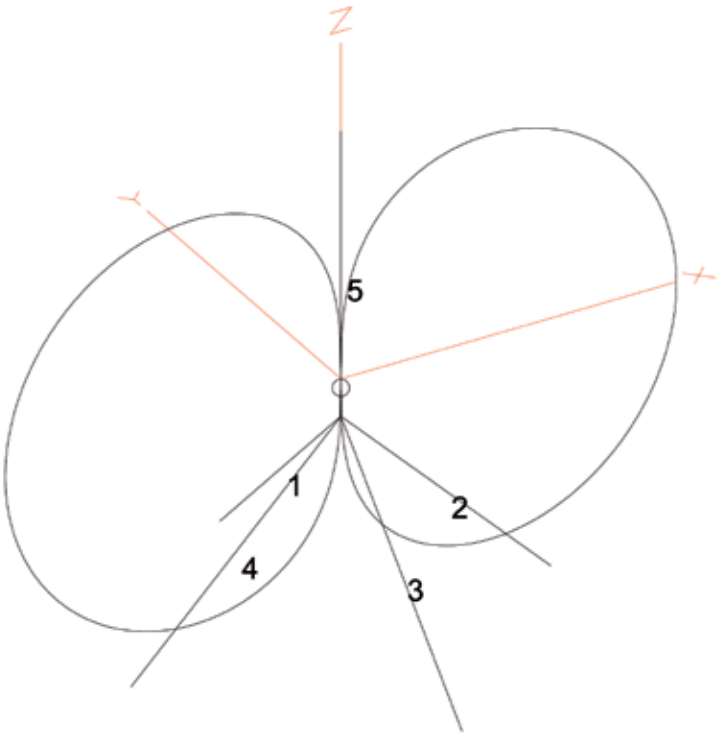


Figure 8. The Romex Ranger gives good circular coverage in the horizontal plane.



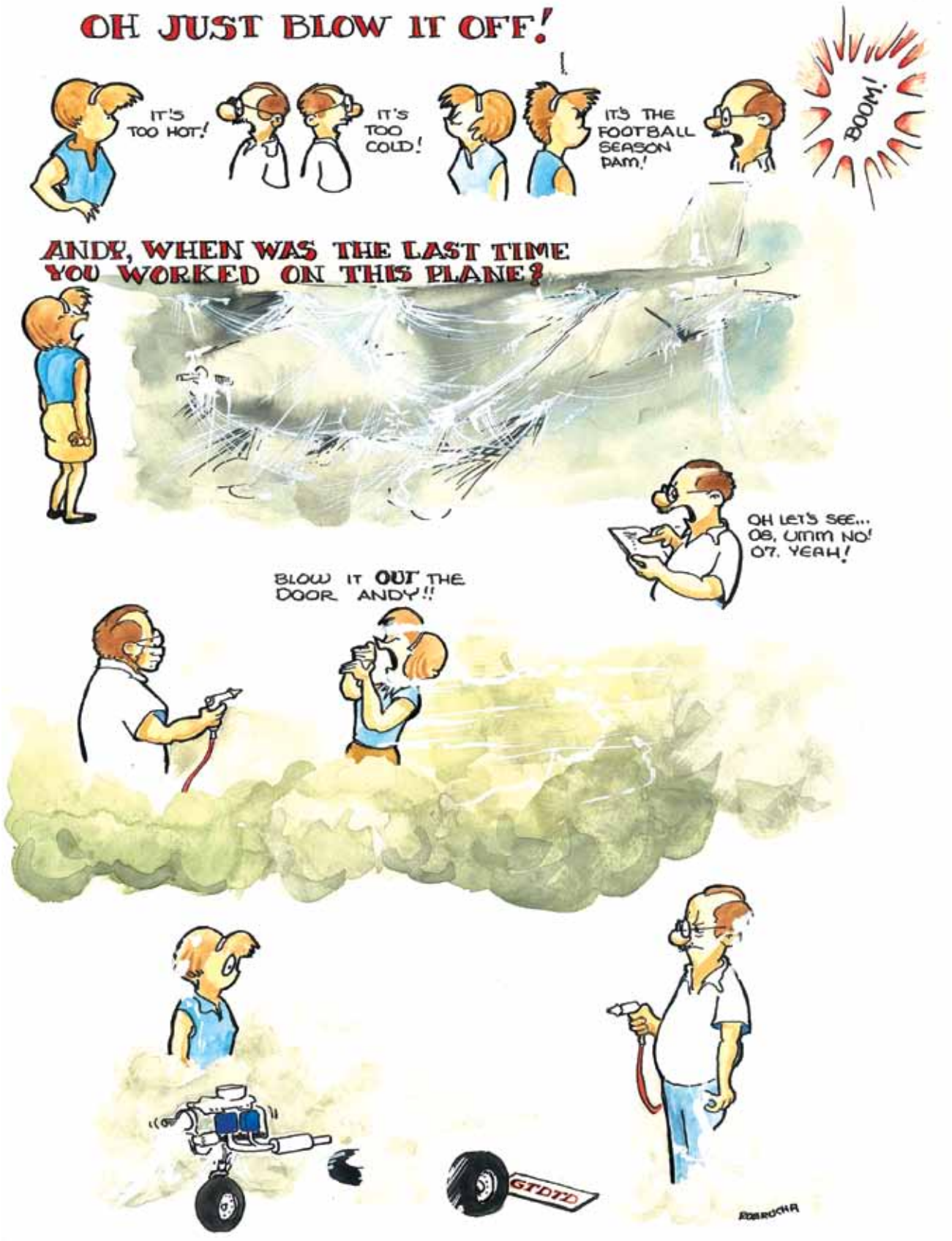
In the vertical plane, we can see that the Romex Ranger is virtually blind when looking straight up.

be just fine. Same for ground stations; rarely are you directly over the Unicom or tower when communicating.

What do these antennas look like as a practical matter? You have pictures of the Ranger from last month's issue, and below is a horizontal dipole antenna being installed into the wing of a plastic airplane; this is the connection of the coax cable to the antenna elements.

I've still got that problem from the boss I mentioned last month with whip antennas getting into the radios and instruments, and making the instrument panel into a Christmas tree; I'll attack that one as soon as I can find one of those old ceramic base, very thin antennas. Stay tuned. ∓

Here is how to connect the coax antenna cable to the elements of a simple embedded dipole antenna.


OH JUST BLOW IT OFF!
IT'S TOO HOT!
IT'S TOO COLD!
IT'S THE FOOTBALL SEASON PAM!
BOOM!
ANDY, WHEN WAS THE LAST TIME YOU WORKED ON THIS PLANE?
OH LET'S SEE... 08, UMM NO! 07, YEAH!
BLOW IT OUT THE DOOR ANDY!!
GTDTD
ROBRUCHA

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