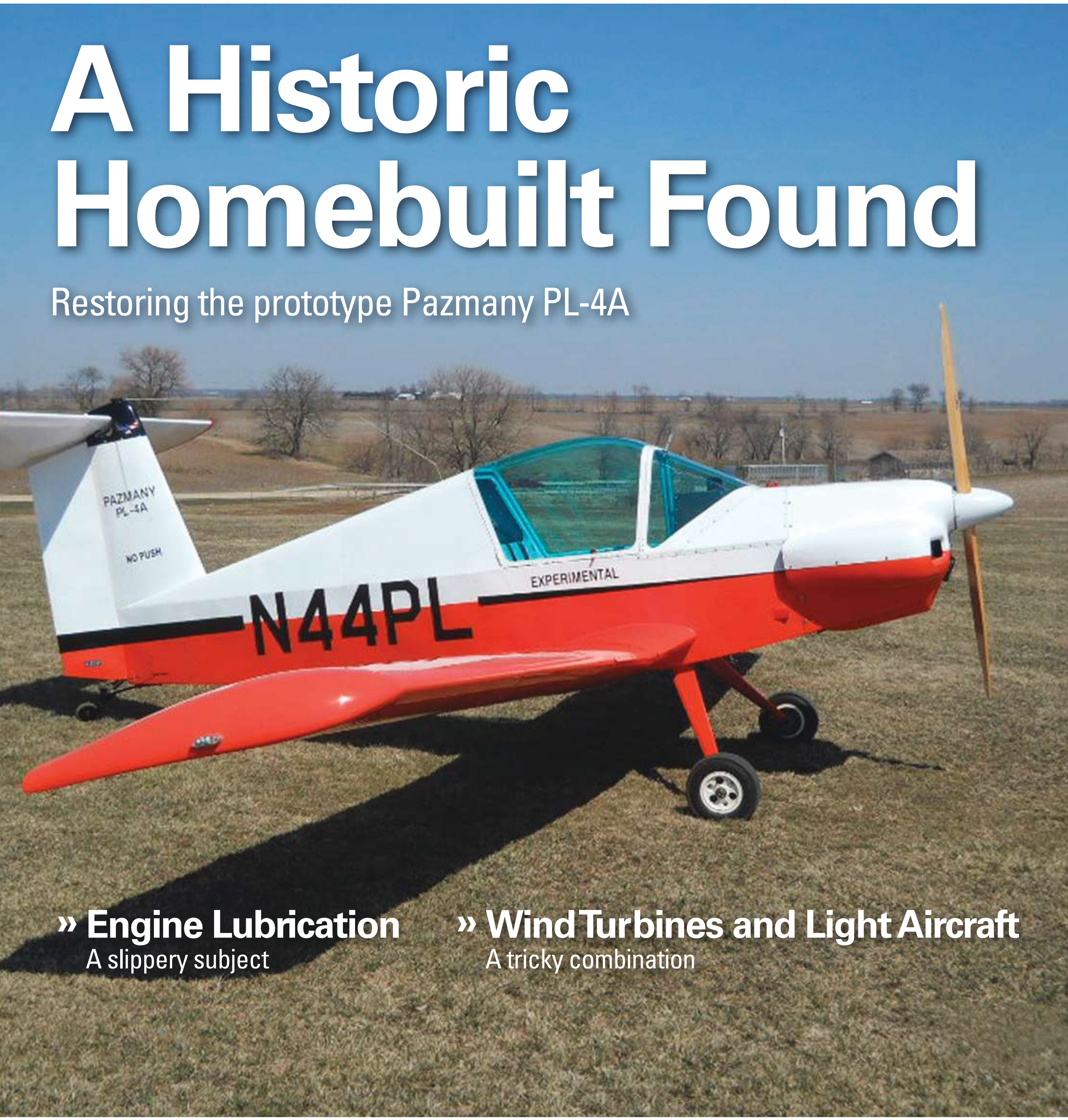
EXPERIMENTER

The Spirit of Homebuilt Aviation | www.eaa.org
Vol.2 No.5 | May 2013

A Historic Homebuilt Found

Restoring the prototype Pazmany PL-4A



» **Engine Lubrication**
A slippery subject

» **Wind Turbines and Light Aircraft**
A tricky combination

Volunteers…
AirVenture wouldn't happen without you

By Rick Weiss, Chairman, EAA Homebuilt Aircraft Council

The spring flying season appears to be off to a good start, at least by the activity observed at the Sun 'n Fun International Fly-In & Expo in Lakeland, Florida, in April. By the time you read this, we'll be less than 100 days away from the start of the largest aviation gathering on the planet. EAA staff planning is well underway, and has been for some time, to identify the areas on the ground that require additional attention, to complete construction of permanent venues such as additional new, air-conditioned restrooms, to prepare the grounds to alleviate trouble areas for aircraft taxiing, and to select and schedule air show performers, among other things.

To accomplish putting on the most diverse and greatest aviation gathering in the world, the EAA staff, which numbers about 120 people, must rely on its most important asset—EAA volunteers. Nearly 5,000 volunteers are involved in ensuring that EAA AirVenture Oshkosh is run safely and smoothly without incident. This has become a part of life for many EAA members. They are the ones who step up and perform virtually hundreds, if not thousands, of tasks that must be done to park and register nearly 10,000 airplanes and make sure that the 700,000 or so attendees can experience the EAA adventure we call AirVenture.

The homebuilt aircraft community is fortunate to have a large share of volunteers. They can be seen parking aircraft, registering and providing transportation for visiting pilots from the parking area to homebuilt aircraft headquarters, judging aircraft, recording live Hints for Homebuilders videos, and providing hundreds of educational forums and hands-on workshops for aircraft builders.

Still other volunteers can be found moving aircraft in and out of the Homebuilt Aircraft Hangar for detailed presentations, which provides visitors with the opportunity to see unique aircraft up close and personal. Volunteers are also involved in staging aircraft for flight as they pass in review during the week. There are other folks who, because of their extensive and unique experience, volunteer to speak at homebuilt aircraft gatherings, such as the Technical Counselor and Flight Advisor Breakfast and the annual Homebuilder's Dinner. Still more volunteers step up to lead the homebuilt aircraft's "feet on the ground" support team by serving on the Volunteer Chairmen's Committee, and of course, the members of your Homebuilt Aircraft Council are volunteers. More volunteers step up to chair and lead every individual tactical area that is required for the homebuilt community to run safely and smoothly at AirVenture. There are also volunteers to assist other volunteers by providing sandwiches and drinks for those who are unable to take time to find lunch. Every volunteer is special and treasured by EAA.

As you have surmised by now, it takes a lot of volunteers to prepare and operate all those activities so that attendees can enjoy the outstanding experience we call AirVenture. As a year-round volunteer, I can assure you the paid staff at EAA is extremely grateful for all who volunteer and help make our annual convention the success that it is, helping EAA be the outstanding organization that it is. From one volunteer to another, thank you for all you do!

I'll look forward to seeing you at AirVenture 2013 on July 29 through August 4. EAA

On the cover: The Pazmany PL-4A restored by Ron Wright and Greg LePine. (Photography by Greg LePine)

EAA EXPERIMENTER

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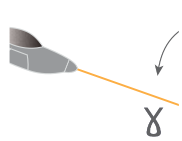

How About an App?

This is really not a good format for the digital version and is a pain to use. Why not have an iPad app like AOPA or use Zinio? This is typical of the first digital formats that were used and basically is old technology for web browsers. Please update to current technology and get your readers going on tablets using current technology. A very good magazine like the *Experimenter* deserves better.

Ron Chauffe
EAA 695709

We agree 100 percent, Ron. EAA is working on apps for both Experimenter *and* Sport Aviation, *and we're hoping they will be ready this summer…perhaps by AirVenture 2013. Until then, you can save it as a PDF and view it on your iPad offline. (That's what we do.) We'll get there. – Eds.*

FlyRotax Is a Great Website, Too

I just read Tim Kern's article in *Experimenter* on buying a used Rotax engine…It was well done and filled with great information. I will refer to it a great deal, I am sure.

I wish you had directed folks to www.FlyRotax.com as well as RotaxOwner.com.

We actually prefer FlyRotax.com. We are members of RotaxOwner.com, and it is a good site; but our primary source of service information comes from FlyRotax.com. This is the factory site rather than a factory-authorized site. In addition to access to continued airworthiness information directly, you can find all the factory-authorized dealers and technicians.

Carol Carpenter
Corona, California

How Do You Read *Experimenter*?

I noticed the note asking for viewer feedback in the April issue, so I thought I'd second the original submitter in saying that the PDF downloads are the best.

I'm a little behind in reading through the last few issues, but I do skim each one on download just for an idea what is inside. But having a "local" PDF is the best for me by far; it's available for me to sit down and read anytime, wherever I am (including on my iPad) regardless of whether I have good Wi-Fi (or not!).

By the way, the same goes for *EAA Sport Aviation* as well…I still like the paper copy when I'm reading at home and use the PDF when away.

Jason Reene
EAA 757522

I am very pleased with *Experimenter* and hope it is continued. I ran across it three months ago and now look for it and read it pretty much in its entirety. I'm not too sure about how to download it, but plan to find out and will save it for future reference.

E. Alan Christiansen
EAA 6929

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AirVenture Adds Midweek Night Air Show

EAA added a second night air show for EAA AirVenture Oshkosh 2013, scheduled for Wednesday, July 31.

"The additional night show is being scheduled this year in response to those EAA members and AirVenture attendees who said they missed this phenomenal event because they came to Oshkosh earlier in the week," said Jim DiMatteo, EAA vice president of AirVenture features and attractions. "We talked with the participating performers, and they're just as excited to have an additional opportunity to fly the twilight show here as the thousands who have enjoyed it each year."

Among the performers already committed to both night shows are:

- AeroShell Aerobatic Team (T-6s)
- Bob Carlton (jet sailplane)
- Matt Younkin (Beech 18)
- Gene Soucy (Showcat)
- Steve Oliver (Super Chipmunk)
- Roger Buis (Otto the Helicopter)
- Rich's Incredible Pyro (pyrotechnics).

Each of the night air shows will conclude with a thunderous fireworks display that has been termed as one of the best in the entire Midwest. All the afternoon and night air shows at EAA AirVenture are presented by Rockwell Collins.

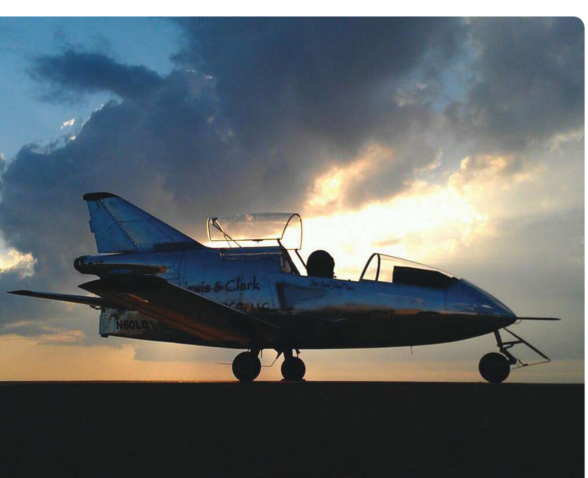
Apply Today for Free Exhibit Space at New AirVenture Innovations Pavilion

EAA's new Innovations Pavilion exhibit and presentation area will showcase what's new and exciting in aviation and space. Along with established innovators, EAA is providing up to 15 free exhibit booths to emerging entrepreneurs.

Located on Celebration Way across from EAA's Welcome Center, the new venue aims to explore the current state of aviation technology and development, and present cutting-edge concepts that inspire participation and imagine the future.

Stage space for daily forum presentations will also be available. Applications are now being accepted for the 15 complimentary exhibit spaces, each measuring 10 feet by 10 feet. To apply, download an application from www.SportAviation.org.

See World's Only BD-5FLS Microjet at AirVenture



Not since the late 1990s has a BD-5J microjet flown at EAA AirVenture Oshkosh, but Justin Lewis, EAA 392017, will bring his BD-5FLS—an upgraded version of the world's smallest jet—to AirVenture 2013.

Over the past dozen years Lewis, a former Young Eagle and Young Eagles pilot, has flown for the military, first as a naval aviator flying F-14 Tomcats, E-6Bs (nuclear command platform); instructing in T-45s; and for the past two years with the Arkansas Air National Guard's 188th Air Wing flying A-10 Warthogs.

Since returning from deployment in Afghanistan in October 2012, Lewis has been preparing for the 2013 air show season.

"I can't use the word 'humbled' enough," he said. "As a kid I remember seeing Bob Bishop and Corkey Fornof and the Silver Bullet Team, and to think I'm now going to fly this aircraft at Oshkosh. Well, I'm kind of beside myself."

Photography by Andrew Zaback

FCC Out of Bounds by Limiting/Banning 121.5 ELTs

EAA has strongly criticized the Federal Communications Commission for its latest attempt to curtail future use of 121.5 megahertz emergency locator transmitters (ELTs), frankly telling the commission that it is infringing on aviation safety policy that rightly belongs to the FAA.

EAA's comments came in response to the FCC's third further notice of proposed rulemaking that invited comments on whether the FCC should prohibit the certification, manufacture, importation, sale, or use of 121.5 megahertz ELTs.

"There is a long list of reasons why we oppose this FCC rulemaking effort, not the least of which is that the commission is overreaching its knowledge and authority by proposing an outcome that FAA has already analyzed extensively and determined to be unjustified in terms of both safety and cost," said Doug Macnair, EAA's vice president of government relations.

"While the FCC has failed to undertake even the most rudimentary analysis in this rulemaking, the most glaring error is that a mandated change to 406 megahertz ELTs does nothing to prevent aviation accidents," Macnair said. "ELTs have also played a very limited role in survival rates post-accident. There is little justification for imposing hundreds of millions of dollars in new equipment requirements on general aviation aircraft owners."

The final EAA comments also remarked that the FCC had failed to conduct any cost-benefit analysis or study on the impact to small business and entities, as required by law. The commission also failed to provide a specific proposal but rather sought comments on a range of proposals that could be part of a final rule.

In addition, the FAA has already stopped the certification of new 121.5 ELT units, which means the GA fleet will eventually move to new technology, whether that is an ELT broadcasting on 406 megahertz or new equipment within the proposed NextGen system such as automatic dependent surveillance-broadcast.

"There's been a long debate over the true usefulness of the ELT equipment, which was mandated by Congress 40 years ago in response to a single high-profile accident," Macnair said. "Regardless of that, emergency locating capability should be based on performance standards and not tied by regulation to specific decades-old technologies.

"The FCC is essential to ensure that any new equipment operates appropriately within the aeronautical frequency spectrum, but this attempt at rulemaking pushes the commission into aviation safety policy that is under FAA control. EAA will strongly oppose any such FCC move."

FAA Announces Change in Special Issuance Medical Certification

In early April the Federal Air Surgeon announced a major change to the medical certification process for several common diagnoses that have previously required a special issuance and a review process by the FAA prior to issuing a medical certificate.

Under the new policy, termed "Certificates an AME Can Issue" or "CACI," applicants with arthritis, asthma, glaucoma, chronic hepatitis C, hypertension, hypothyroidism, migraine and chronic headache, pre-diabetes, or renal cancer can receive their medical certificates directly from their AME. Further diagnoses are expected to be announced in the coming months.

The AME will require certain documentation, but this does not have to be forwarded to the FAA as in the case of a special issuance. The resulting medical certificate is good for the normal duration, depending on the age of the applicant and/or the class of medical.

Members of the EAA Aeromedical Advisory Council were heavily involved in bringing about these changes. "We are incredibly fortunate to have the Aeromedical Advisory Council at EAA," said Sean Elliott, EAA vice president of advocacy and safety. "These six AMEs are among the most experienced and respected doctors in the aeromedical business, and this announcement represents the culmination of several years of hard work." EAA

Evektor's Electric SportStar EPOS Makes First Flights

Czech aircraft manufacturer Evektor-Aerotechnik flew its electric-powered SportStar EPOS airplane for the first time on March 28 at the Kunovice Airport in the Czech Republic. Evektor's factory pilot, Radek Sury, made two flights totaling about 30 minutes.

The SportStar EPOS (electric-powered small aircraft) derives from Evektor's SportStar RTC and is being developed for private customers as well as flight schools for primary pilot training. According to the company, EPOS is powered by a 50-kilowatt Rotex Electric RE X90-7 motor and employs a new, extended trapezoidal wing. Subsequent flight tests will examine the function of the power unit and its effect on the plane's flight and operational characteristics.

The SportStar EPOS project received the financial backing from the Czech Republic's Technology Agency, and involved other Czech companies including Rotex Electric, prop manufacturer Aerospace Research and Test Establishment, MGM Compro (motor control unit), and Faculty of Information Technology of Brno University of Technology, which supplied the display unit for motor parameters.

For more information, visit www.Evektor.cz.

Pipistrel Panthera Flies for the First Time

Pipistrel's sleek, new Panthera flew for the first time on April 4, 2013. The Panthera is Pipistrel's first four-place GA aircraft. The 54-minute flight by test pilot Mirko Anzel and co-pilot Saso Knez followed several high-speed taxi tests and runway hops at the company's headquarters. The Panthera, Pipistrel's first non-LSA/ultralight, was first unveiled at Aero Friedrichshafen 2012.

The Panthera is made of composite materials with a retractable titanium landing gear. The company claims the aircraft can fly four people for 1,000 nautical miles at 200 knots at a fuel burn rate of 10 gallons per hour. The prototype is powered by a 210-hp Lycoming engine, but Pipistrel envisions Panthera can also be configured with hybrid or all-electric propulsion systems. A ballistic parachute system is standard.

The airplane performed exactly as expected, with handling described as "straightforward and pilot friendly," the company stated. First and subsequent flights were flown with gear down and retracted.

"This is Pipistrel's first entry into the world of general aviation," commented Ivo Boscarol, Pipistrel CEO. "We knew for a long time that we were capable of developing and producing aircraft larger and more capable than ultralights/LSA. Panthera is proof that Pipistrel's team can indeed compete with the most eminent global general aviation producers."

Panthera is also significant as it's Slovenia's first ever four-place production airplane. For more information, visit www.Panthera-Aircraft.com.

Panther Sport Prototype Completes First Flight

Sport Performance Aircraft LLC successfully flew its prototype Panther Sport aircraft for the first time on April 8 at Kay Larkin Airport (28J) in Palatka, Florida. The mid-size, single-seat, low-wing, aerobatic airplane flew for approximately 20 minutes and experienced no issues with controls, performance, or handling, according to the Panther blog.

Dan Weseman, SPA president, spent several years designing the Panther and built the airplane over the past year. Panther is an aluminum and welded steel airplane with folding wings.

After passing inspection on March 29, the first taxi occurred on April 2. Designed and built at SPA headquarters at Haller Airpark in Green Cove Springs, Florida, the Panther is what Dan and Rachael call the "Burger King of airplanes" for its "have it your way" options. The aircraft's versatility allows pilots to choose the plane's engine, landing gear configuration, wing length, safety features, open or enclosed cockpit, and kit or plan/kit combo.

The prototype's engine is a 120-hp, 3.0-liter Corvair built by William Wynne of FlyCorvair. Other engine options will include Continental C-85, O-200, O-240, Lycoming O-235 to O-320, ULPower, Jabiru, or VW.

Eventually, Dan and Rachael hope to sell this aircraft as a kit. There will be three wing lengths/airframe configurations: Sport, LSA, and Long LSA. You can learn more about the Panther on the company's Facebook page, FlyWithSpa.

Final Push Is On for Bugatti 100P Racer Project

About two and a half years ago Scotty Wilson, EAA 572551, of Tulsa, Oklahoma, traveled to Oshkosh to examine the original Bugatti 100P racer that's on display in the EAA AirVenture Museum. The project now is nearing completion in his hangar at Tulsa, Oklahoma.

"Ninety percent done with 90 percent to go," Wilson said in early April. "It's very close to done. We might be able to roll the plane out of the hangar in mid-June." He hesitates to pin a date to anything; but it's reasonably possible Wilson's airplane could do taxi-testing and even a first flight before the end of the year, but no earlier than the fall.

Wilson's first flight would be a true maiden voyage for the futuristic airplane. Designed in the 1930s by famous automaker Ettoré Bugatti and engineer Louis de Monge, the original Model 100P never got off the ground. As the German army advanced on Paris in June 1940, it had to be disassembled and whisked away so the advanced technology didn't fall into enemy hands. Wilson calls it "the most historically significant airplane that never flew."

One of the plane's crucial—and most complex—components is the gear box, which has finally been finished after two and a half years of design, revision, and production. It is set to arrive in Tulsa the first of May from S&J Engineering in Hinckley, United Kingdom, which agreed to take on the project after another firm pulled out.

Wilson hopes to have the 200-pound gear box installed and the propellers on soon, at which time the airplane will be pulled out of the hangar for the first time. The props were designed by Swedish propeller theoretician Jan Carlsson and fabricated by Rupert Wasey at UK-based Hercules Propellers. Two 200-hp Hayabusa motorcycle engines will power the craft, Wilson said.

"We are certainly in the final push," he said. "This airplane is an extraordinary machine. It really makes one appreciate the genius of de Monge. He did it himself—just one guy—which makes it all the more impressive."

Follow along as this project heads for the finish line at the Bugatti 100P Racer project Facebook page. EAA

A Lost and Found Homebuilt

The saga of a Pazmany PL-4A

By Ron Wright

First it has to be understood that I did not set out looking for, or wanting to own, a Pazmany PL-4A. In fact, I didn't even know what a PL-4A looked like. Nor did I ever think I'd be restoring a historic homebuilt. In fact, this entire adventure began with an originally designed ultralight aircraft, which was the brainchild of a pilot friend of mine who unfortunately became ill and was unable to continue with his original concept, a J-3 Cub look-alike.

During an EAA meeting in January 2010, I mentioned to Greg LePine, a friend and fellow chapter member of EAA Chapter 563 in Peoria, that I was going to rent a space in our chapter hangar and begin working on a Cub look-alike. Before I could ask, he volunteered to help me build that project.

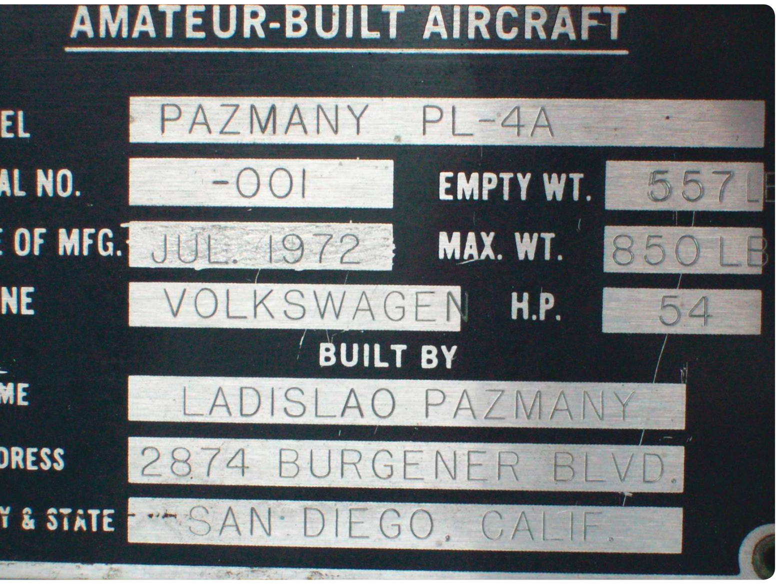
Greg's building talents are multidimensional and proved to be exactly what the Cub project needed. However, neither of us could have imagined what we'd team up on next.

May 2011: The Paper Chase Begins

Greg and I were working on the "Cubbie" when another friend told us of a project that was available. He was

The original 40-hp VW conversion engine with a multi-sheave V-belt redrive wasn't salvageable. Pilots who flew the PL-4A with this engine felt it was underpowered.

Ron didn't recognize the name on the tail surfaces when he first saw the aircraft.



The original dataplate remains on the restored PL-4A.

insistent that I should come see it at his local airport in Canton, Illinois. Later that week I walked into his hangar and saw a terribly forlorn-looking little airplane barely visible under a mountain of stuff.

All I could see initially was a cruddy white-over-orange hulk of an airframe that had been sitting in that corner for about three years. The owner had passed away in 2011. According to his widow, he bought the aircraft on eBay in 2008 but never had a chance to start working on it.

Apparently, from 2002 to mid-2008, this aircraft had been stored in a storage unit in Huntsville, Alabama. After the rental fee had not been paid for some time, the storage business owner placed the eBay ad in an effort to recover some of the rental fees. After winning the auction, the proud new owner trucked his airplane home and tucked it away in a hangar, where it still resided when I came on the scene. I've been unable to uncover any of the airplane's history from 1978 to its arrival in the rental facility in 2002. Perhaps someone reading this can help me fill in the gaps.

As I studied the all-aluminum, single-seat, taildragger, it appeared to be fairly complete. I told the widow that I would do some research to determine what the airplane was and what the FAA paperwork had to say about it.

The FAA folks in Oklahoma City said that the paperwork on that particular aircraft was, to use their term, "clouded," so I ordered the CD history and went to work. It didn't take much reading to agree with the Feds that the paperwork was, indeed, "clouded." Actually, it was terribly incomplete. That aircraft had lost its airworthiness certificate in 1978, and there was no registration or ownership indicated; so basically there was no paperwork for that aircraft after 1978. As far as the government was concerned, the airplane didn't exist. I had my work cut out for me. But I didn't let it slow me down. I decided to buy the aircraft and then try to straighten out the multitude of problems with the paperwork. In essence I had committed to buying and restoring an airplane that I couldn't even identify. I had no idea what it was regardless of the cryptic "PL-4A" on the tail. However, even the most casual examination showed that it was a high-quality airframe, so I was more than willing to take a chance on it.

The widow accepted my first offer but stipulated that I remove the airplane from the storage facility within seven days. Three days later we had the airplane safely tucked away in my hangar.

We had loaded the airplane and were about to take it home, when Greg said that he had seen a plane "that looked just like this one" in an aviation magazine. He compared the N-number on the moldy-looking plane we had bought to the one in the article, and that's when we discovered that we had the original prototype of the Pazmany PL-4A experimental aircraft from 1972. Holy Toledo!

Greg and I decided to hold off working on the airplane until we got the FAA's blessing on the paperwork, which took much longer than we expected. Three solid months of research and continued communication with the FAA was invested before it said that I had accomplished what we'd set out to do: I had provided enough information that it would legally register the airplane to me. Even better, it would allow the airplane to retain the original N-number, serial number, data plate, and builder's name: Ladislao Pazmany!

Success! Time to Start Working

The new registration is dated August 2011, and it's hard to describe how excited and relieved we were. Now that ownership of N44PL was established in my name, Greg and I could get to work, which comprised laying out the sequence of steps we'd take in doing the restoration and laying out our goals for the project. They included:

1. To restore this historically significant experimental aircraft to its original 1972 configuration.
2. To deconstruct every part, assembly, and component to determine if it was safe to reuse or was to be replaced.
3. To use as many of the original components as possible to help retain the character and legacy of the original aircraft.
4. To restore the airplane to flying condition, not as a

Ladislao Pazmany

Ladislao "Paz" Pazmany, EAA 2431, was born in Hungary but grew up in Argentina. Enamored with aviation from an early age, he built models and began flying gliders when he was 15. After obtaining a degree in aeronautical engineering, he worked wherever engineering jobs were available in the unstable economy that prevailed in Argentina at the time. For nearly a decade he designed aircraft, pipelines, high tension power line towers, suspension bridges, chemical and hydroelectric plants, was an instructor at an aeronautics school and worked as an auto company draftsman — sometimes holding as many as three jobs at a time!

In May of 1956, Paz and his family moved to the United States and settled in San Diego, California, where he went to work for Convair. The following month he attended his first EAA Chapter 14 meeting. At Convair, he worked on the F-102, F-106, and other projects…and, along the way, obtained seven patents for inventions ranging from aircraft thrust reversers to emergency natural gas shut-off valves that activate during earthquakes.

Concurrent with his full-time employment, Paz devoted his spare time to his first love, personal aircraft. He designed the PL-1, which flew for the first time on March 23, 1962, made plans available to homebuilders and wrote the book *Light Airplane Design* --all of which allowed him to start his own business and devote more time to lightplane design and development. In the late 1960s, the Nationalist Chinese Air Force acquired plans to build a version of the PL-1 to serve as a primary trainer. That prototype flew on October 26, 1968, and an additional 35 aircraft were started that year. Meanwhile, Paz had designed an improved version of the PL-1, the PL-2, and the first one flew on April 4, 1969. In the early 1970s Paz began work on the single-place PL-4, and the prototype was flown on July 9, 1972. Plans were made available for each of the designs and they are still being built today.

In the 1970s Paz created and for several years conducted the Pazmany Efficiency Contest at Oshkosh, which gave EAAers one of their first real-world evaluations of homebuilt performance. In the early 1970s Paz became the chief engineer for aviation legend T. Claude Ryan's Ryson Aviation Corporation and designed the Ryson ST-100 Cloudster, a beautiful powered sailplane that was formerly introduced to the flying world in early 1977. The work Paz did designing the Cloudster's landing gear led him to write the book, *Landing Gear Design for Light Aircraft*, which has become the standard work on that subject and is on the shelf of every aircraft designer today.

Pazmany, who was inducted into the EAA Homebuilders Hall Of Fame in 1997, passed away in 2006 at the age of 82.

show aircraft. We wanted to fly it and have fun.

5. To research its history and make that research part of this restoration.
6. To have the airplane finished and displayed at EAA AirVenture Oshkosh 2012, the 40th anniversary of the PL-4's birth.

Prior to starting the restoration, I e-mailed Margarita Pazmany, Ladislao's widow, and I told her that I had this aircraft and asked if she would be interested in reacquiring it for her company. She declined our offer and wished us well with the restoration. Much more importantly, she sent me a complete set of original builder's plans, a builder's manual, and a signed certificate indicating that I was the owner of N44PL, Serial Number 001. She did all of this without being asked and at no charge. What a gracious lady!

Dismantling Observations

During the dismantling process, Greg and I sorted out the reusable items and stored those items that we would not use but wanted to keep as part of the legacy for this aircraft.

We were pleased and surprised to find that overall this aircraft had been well protected and had not flown after 1978, based on the last tachometer time entry in the original logbook. It had very few hangar rash dents in any of its aluminum surfaces, which was pretty amazing considering how much it had been moved around. It had accumulated the expected dirt, grime, and bird and mouse droppings, so cosmetically it looked incredibly grungy, but the basic bones were in very good shape.

We also discovered that this aircraft was built more like a production fighter aircraft rather than the average homebuilt, which I guess we should have expected. After all, Ladislao Pazmany was an aeronautical engineer and designed fighter aircraft for a living.

The list of stuff that we'd have to replace included all the electrical wiring, tires, tubes hydraulic brake pads and lines, engine accessories, radio/navigation systems, and many of the instruments. The internal pitot tube lines, AN hardware, prop, belted redrive system, and other sundry items would be replaced only if needed.

After deconstructing the PL-4A, we discovered several areas that needed more attention than originally anticipated, meaning that this aircraft would not make Oshkosh 2012. That didn't make us very happy, but we soldiered on.

Restoring and Just a Little Improving

There were several areas where we made improvements during the restoration process:

The Pl-4A as it looked when Ron and Greg hauled it to the Chapter hangar.

Greg LePine (left) and Ron Wright congratulate one another on completing the restoration of the PL-4A.

1. The original VHF/VOR indicators never worked properly and were replaced by a vintage Terra 960 TXN unit that passed its bench tests with flying colors.
2. With a lot of hard work, Greg was able to resurrect the original windscreen and canopy assembly and make them better than new.
3. The original 40-hp VW conversion engine with a multi-sheave V-belt redrive had to be replaced with a new 65-hp Great Plains 1915-cc VW conversion engine with a 1.6-to-1 belted redrive cogged-belt reduction unit. The original engine was assembled from a collection of parts obtained from local auto salvage yards. An often-heard comment from pilots who originally flew this aircraft was that the engine was underpowered.
4. The accessory case was reworked to hold an aircraft-style Slick magneto and a starter ring-gear. The ring-gear attachment rivets always gave this engine problems and had to be repaired on numerous occasions. A five-belt Huggins prop re-drive system with a 2.25-to-1 ratio was part of the original engine package, which allowed the use of a longer prop turning at a slower speed to produce greater thrust. The original prop was a two-bladed wood Hendrickson, with a 68-inch pitch and 72-inch diameter.
5. The original Hurst-Airheart hydraulic brake units were rebuilt with new parts from the same company.
6. New main gear tires and tubes were easily located that fit the original small go-kart 3.5/4-by-6 wheels.
7. We wanted to apply a completely new paint job from the ground up, maintaining the original paint colors and distinctive white-over-orange scheme.

Friends of the PL-4A Come Out of the Woodwork

The paint was problematic because neither of us are painters. At first, we thought that we might be able to rejuvenate the original external paint but quickly came to the conclusion that the original paint needed to be completely removed and the entire aircraft repainted to its original configuration. The challenge was to find a shop that had the talent and the interest to take on that process for a reasonable fee.

After interviewing three shops that really didn't want to take on the stripping, priming, and repainting tasks, Greg remembered a locally owned shop with which his company had done business in the past. We made contact with that owner, George Wall of Midwest Production and Restoration in Glasford, Illinois, and presented our dilemma. He wouldn't let us leave his office until we promised that he would get the job; and he quoted a price that brought tears to our eyes because it was so good! George became another co-sponsor on the spot.

All of these restoration processes take time and money. Greg and I are both retired, so we had the time. It was the money that would determine our rate of progress with the restoration. So, operating on the premise "Ask and you shall receive," we initially invited four aviation-related vendors to "co-sponsor" our efforts with this restoration. The results were nothing short of amazing! Wondrous things happen within the aviation community, and in a very short time all four vendors responded positively to our invitation. Based on their responses, we expanded the co-sponsorship list, which has grown to a total of 22!

Lots of Folks Had Flown It

While doing research on this aircraft, Margarita Pazmany showed me an original logbook for this aircraft that lists the names of many aviation notables including Budd Davisson, Don Downie, Don Dwiggins, Walt Mooney, Peter Lert, Peter Garrison, and Mitch Garner, each of whom had flown this aircraft in the 1970s.

Aside from having the unique opportunity to work with Greg's "let's get 'er done" attitude in actually accomplishing a restoration on such a historical aircraft, I found that everyone who learned about what Greg and I were doing were as excited as us and would volunteer to help in any way possible. This participation is a testament to just how great America, EAA, the aviation community, and everyday folks are when the "cause" is something as unique, infectious, and downright symbolic as this Pazmany PL-4A.

Greg and I are humbled to have had the great opportunity to restore this aircraft and to have been associated with the many co-sponsors and individuals who have all helped us in our efforts.

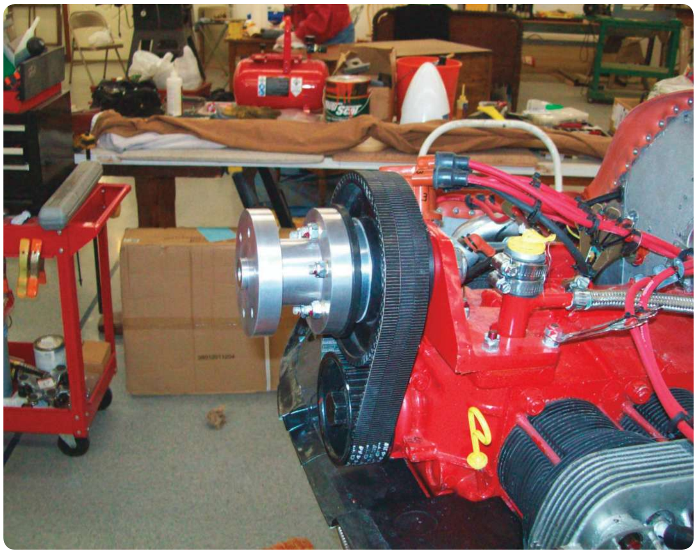
I made an initial flight in the PL-4A on December 17, 2012, climbing to about 25 feet above the runway for about 200 feet, then landing due to an oil leak in the right valve cover. It wasn't until much later that the significance of the date dawned on me. It was the same day another Wright, Wilbur, had taken to the air 109 years earlier.

P.S. Once, I tried to reserve some motel rooms for AirVenture Oshkosh for my brother and me. When I asked to reserve some rooms in the name of the Wright brothers, the desk clerk quickly advised he didn't have time for that kind of foolishness. He didn't realize I wasn't kidding.

Plans for the airplane are still available. They are professional-quality aerospace construction drawings, not the kind you'd expect for a homebuilt. Visit www.AircraftSpruce.com. EAA

The fuselage ready for painting.

The restored PL-4A flew again for the first time on December 17, 2012, a fitting date for a first flight.



A new 65-hp Great Plains engine now powers the aircraft. Its a 1915-cc VW conversion with a 1.6-to-1 belted cogged-belt reduction unit.

Ancient Words

At last! A Simple Pazmany!

By Budd Davisson

It's hard to believe that I wrote the following words 40 years ago for Air Progress in June 1973. I had just flown the prototype Pazmany PL-4A, but not for a second did I think that four decades later I'd still be talking about it. This is a good little airplane and a perfect scratchbuilt light-sport aircraft. Besides being relatively simple, it uses a belt-reduced VW, so it can be built economically. Hey, nothing wrong with a good airplane regardless of the age.

As I sat at the end of the runway, I panicked for a second when I couldn't find the mag switch. Then I remembered that with a VW it's a go or no-go situation. If the engine is running, the ignition is okay; if it isn't running, I shouldn't go flying. Seems simple enough.

The test pilot had warned me that the PL-4 was fairly sensitive in the pitch mode, so I should be careful bringing the tail up. It's a good thing he warned me. I gave it full power, which means the engine is cranking nearly 4,000 rpm and sounds as if you're doing 200 mph. With about 50 horses available, the acceleration doesn't make you swallow your gum, but when we were clipping along and I started to raise the tail, I got my first surprise of the flight. It is sensitive in pitch; because the tail jumped up, and I had to bring the stick back quickly to keep from plowing pave¬ment. It was easily corrected, but it's something to watch for, at any rate.

A 300- to 400-fpm climb isn't going to wow many aerobatic or warbird types (Editor's Note from 2013: This was with a stock 40-hp VW. A later, bigger VW would make a rocket ship out of it), but I'd like to see their airplanes do as well with this much power. It takes a little while to get out of the pattern at 60 mph, but I needed the time to get a feel for the controls anyway. When I first left the ground and started fighting gusts, I found that either my hand had sud¬denly turned to ham or the PL-4 had very sensitive controls.

At altitude, I investigated the con¬trols more thoroughly. After batting it around a little, I found the problem wasn't one of light controls; it was the fact that you didn't have to move them very far, and they didn't have the conventional amount of friction. Your feet become very useful in turns, because the long wing and its unusually high aspect ratio of 8:1 generate lots of adverse yaw that even differential ailerons couldn't completely correct. It's actually a very easy airplane to coordinate, but you have to think about it first. To check stability, I'd bash the stick forward or to one side and release it. The airplane would jump and then return to level flight. Many homebuilts don't have this stability, especially in pitch.

It's really wild to be bouncing along, trueing about 80 mph and looking at a tach that reads 3,000 rpm. The big 74-inch prop made very little racket, but the tone of the exhaust made me feel as if I were tailgating a Beetle.

With the spook tales about T-tails in my mind, I set up for stalls and came in very gently with the back pressure. Down around 45 to 50 mph, it gave a sharp jump and the nose started down. The initial sharpness surprised me a little, and I didn't waste any time recovering. The next time, I decided to hold it back to see what would happen. Again it broke rather sharply, with the left wing dropping slightly. But almost as soon as it broke, it stabilized in a mush. What had appeared at first to be a bad stall was actually just a sharp break; once stalled, it is thoroughly docile and easily controlled.

The most interesting part of any first flight is the landing, and this one was all the more interesting since some klutz in a 182 turned inside me and cut me out on final. Against my better judgment, I slowed down and came in behind him, holding 80 in¬dicated, which was actually 60 true. I remembered the sharpish-breaking stall and flew it right down to the ground before bringing the nose up. Then, just as I was about to touch, I caught either a gust or the Cessna's wake and started drifting sideways at a speed I didn't think I could correct for without digging in a wingtip. I hit the power to go around, correcting for the drift as I did. I touched the runway for a second before taking off again and saw immediately that I could have probably gone ahead and land¬ed, because crossed controls did stop the drift. I went around anyway, fi¬guring I'd made one mistake already—no reason to compound it.

The next several landings were completely uneventful, if you can call consistently landing two feet in the air uneventful. I just couldn't seem to judge my height, and the airplane would quit flying before I could find the ground. At least I proved that the PL-4 will take care of itself.

My only real complaint with the airplane was that its quick controls might scare the devil out of the builder on his first flight. Often a man who has taken the time to build an airplane hasn't kept up his piloting skills and is not as sharp as he should be when he test-hops his airplane. Pazmany realizes this and is now working on a way of increasing con¬trol feel. (Editor's Note: This was rectified.) He's also planning to experi¬ment with all the various VW modifi¬cations, the Kiekhaefer engine, and the old 65-hp Lycoming and Conti¬nental standbys. He expects perform¬ance to jump when he gets a true 65 hp out front.

It's an unfortunate part of sport aviation that people are often attract¬ed to airplanes that are beyond their abilities as pilots or builders, or both. The Pazmany PL-4 is a fine solution to the problem. It's inexpensive, easy to build, and it can safely be flown by anyone who can handle a Cub. The PL-4 is the kind of airplane people should be building, but aren't.

Bob Frisby (right) and I at Big Creek, Idaho, The airstrip is at 5,743 feet surrounded by 10,000-foot peaks. Here is a video of this landing with a 12-knot tailwind.

A D-I-Y Glass Panel

My technical journey

By Bill DeRouchey Jr.

Photography by Ken Paddon

Occasionally, it is best not to think too much.

Much like Alice falling down the rabbit hole, I never knew where the road would lead when I became "casually" aware of Van's Aircraft in 1995. It was all very interesting; but we (my wife, Sara, and I) needed a comfortable four-place aircraft, and the existing Van's offerings seemed too snappy for cross-country travel. But then rumors began to be heard, projected specifications were published, and pathetically poor pictures surfaced of a four-seater under development. When Dick Van Grunsven wrote his pilot report on the new RV-10, we believed, mostly on Van's values, that this was the airplane for us. In July 2003 we received an order form and mailed it the next day, becoming Kit No. 29. The big box was delivered in October, and my life changed forever. And most amazingly, we have never regretted what was basically an emotional decision.

Grinding It Out

The airframe building moved along mindlessly, prepping, drilling, and riveting the aluminum pieces together. After watching the prices of four-cylinder Lycoming engines react to the volume of Van's earlier products, I jumped on a pristine, 20-hour SFOH Lycoming IO-540 and lovingly tucked it away for a later day. Around June 2005, I realized that the airframe and engine completion was easy to visualize, but how would I transform the blank aluminum plate into a functional panel?

Remember, in 2005 the avionics choices were not what they are today. I looked at Garmin, Chelton, Dynon, OP Technologies, and Blue Mountain, rejecting each of these vendors for a variety of reasons. I had been designing and implementing computer solutions since 1969 in my day job. But my last 12 years were in engineering management, and my technical skills were rusty. What if I designed the entire panel? Could it be accomplished safely?

Mitigating Fears With Design

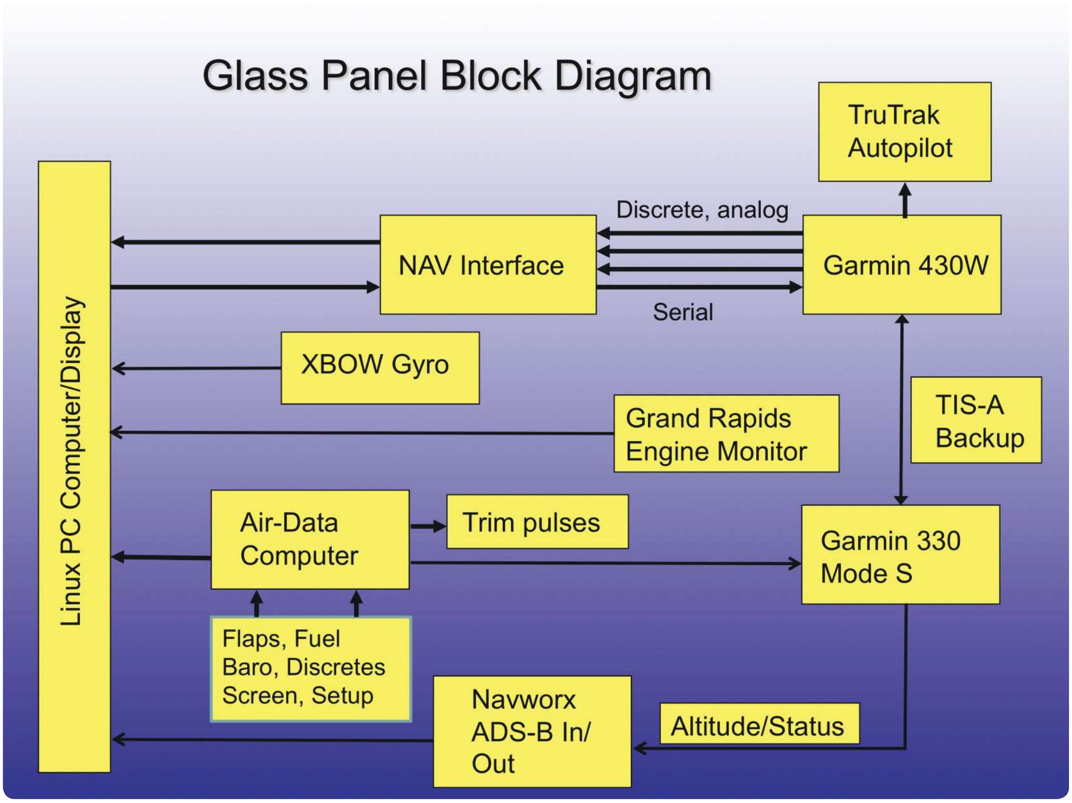
I began laying out the system design for a personal computer–based glass panel and identifying the make or buy components. After a lunchtime chat with friends, it was obvious that I was starting at the wrong place; backups need to be defined first. But you can't define backup instrumentation until you have a mission.

If you think it through and internalize the mission as gospel, the backup equipment alone must fulfill the mission. A tight definition of our cross-country mission is "If there is a problem, then we will continue to our next waypoint, land safely under any conditions, and thereafter fix the aircraft." Of course, route planning must include strategic waypoint selection. Another major consideration was that the glass panel was going to be a multiyear development, interwoven with family trips, and may not be perfect.

To meet these goals, I implemented TSO-certified round instruments and a Garmin SL-30 (radio, VOR, and ILS) powered by a separate standby bus and battery. The standby master switch is wired to deplete the standby battery, and if necessary, then deplete the main battery. Other than audio and a trickle charger circuit, no other connections exist between the backup and primary components so one cannot affect the other. On just one inexpensive 12AH standby battery, our RV-10 will fly in instrument conditions for 1.5 hours and shoot an ILS approach with the master switch off. From a design point of view, this was an excellent strategic decision because I didn't need to implement any backup considerations in the glass section and probably saved money overall.

A small but interesting puzzle was solved by the Garmin audio panel. If the headset is wired into the audio panel and the power to the audio panel is off because the master switch is off, then how can the headset work with the backup radio? In every audio panel that I have wired, there are normally closed relays that bypass the internal audio panel logic and directly tie the pilot headset to "Comm1" when the power is off. So my backup Garmin SL-30 radio is "Comm1" and the Garmin 430W is "Comm2."

Since the backup instrumentation is "anded" into the primary panel, several unforeseen bonuses began to emerge. With the standby master on, additional radio frequencies could be queued into the SL-30 when entering complex airspace, and a glass panel GPS WAAS approach could be monitored with the backup ILS should an outage occur during a critical time. Recently, I was in actual weather on a GPS WAAS approach, and the LPV was suddenly downgraded to an LNAV approach. I simply refocused and flew the ILS approach, never touching a button.



Core System Design

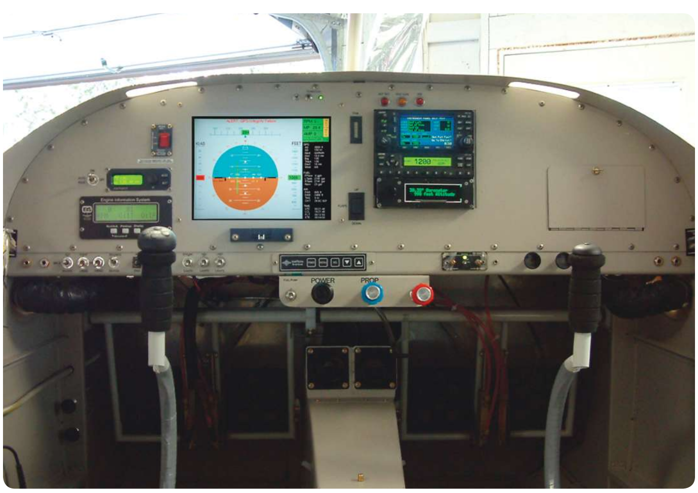
The initial glass panel goals were quite simple, yet had far-reaching results. No vacuum system would be installed, and we would maximize the display size, minimize the number of buttons, and use off-the-shelf components wherever possible. The components needed to be integrated such that the same data is never entered twice.

The logical approach was a distributed system design with smart components interfaced to a Linux PC (display) via serial lines. Since the display computer sees all data, it can integrate information to create higher-level metrics. As an example, to accurately calculate fuel at destination you need remaining route distance, ground speed, fuel levels, and fuel flow. This requires data from three different components.

Scotty, my instrument instructor, would always tell me the autopilot could save my life. I remembered his words and powered the autopilot from a separate switch and connected it directly to the Garmin 430W. This independence will maximize the autopilot's usefulness during an emergency.

I performed all the hardware engineering and programming for the nav interface and air-data computer (ADC). The nav interface box organizes the many Garmin 430W outputs into packets and sends them over the serial link, and the ADC calculates all the air values and becomes the garbage collector for many miscellaneous inputs and outputs. It was an interesting task working through the air data and digital smoothing mathematics.

I settled into a regimen of working on the airframe during the day and programming at night.



First Flight

In August 2006, the panel and airframe were ready for the first flight. The actual flight was uneventful and all systems worked fairly well. After a few flights, though, it was obvious that the elevator trim system was too sensitive as the RV-10 reached cruise speed. I implemented a solution by modifying the ADC component. My idea was to output a voltage pulse from the ADC to the trim servos that became shorter as the airspeed increased. After two or three iterations, I could feel no sensitivity change from landing configuration to high cruise. It was one of those satisfying moments of elegantly solving an unforeseen problem within the original design. I did, however, add a switch to bypass the ADC trim motor pulses with a fixed-bus voltage in case the ADC failed.

The first panel was a simple prototype to check out the system. I continued to fly this panel for another six months while I matured the software. Most of the modifications pertained to calibration routines and rendering yet another primary screen. The personal reward of making software modifications and then observing the changes in flight was immeasurable.

In March 2007 I ripped out this panel and started over.

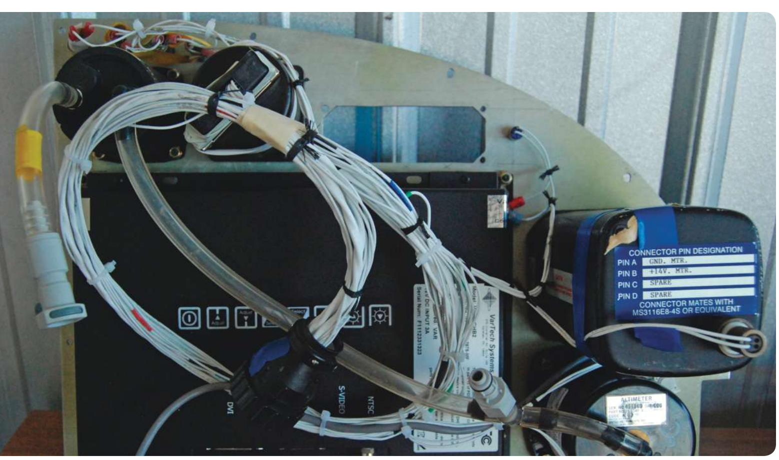
Ergonomics

This is how our RV-10 panel looks today with square primary and round backup instrumentation. As you can see, except for backup instruments, the panel is clean, symmetrical, and designed for easy maintenance. Stein Air produced a panel blank that was very well thought out and became a fine foundation.

I chose two 10.4-inch sunlight-rated displays because nothing larger would fit. They are coupled with a VGA amplifier and show the same images. Yes, the same images, and it was a brilliant decision. I've seen panel designs completely oriented toward the left seat, even using canted segments to optimize pilot viewing. This design may provide some comfort for the pilot but psychologically demotes the right seat. Using the co-pilot display, Sara can conveniently see how the flight is progressing, can help look over weather issues ahead, has good input into the alternatives, and feels involved in the flight. This has worked out great; she wants to go on trips, knows that everything is okay, and understands the value of adding equipment to my terribly expensive hobby.

Another reason the cockpit looks clean is because many of the fuses are behind the panel, and emergency controls are inset at the pilot's left knee. Any fuse that is associated with a control is located on the panel.

I knew from the beginning that the airframe and engine would be stable, but many, many panel changes would be necessary. The solution was to design the two large side panels to pop out quickly for full access. This allows me to work sitting up and not lie on my back working overhead.



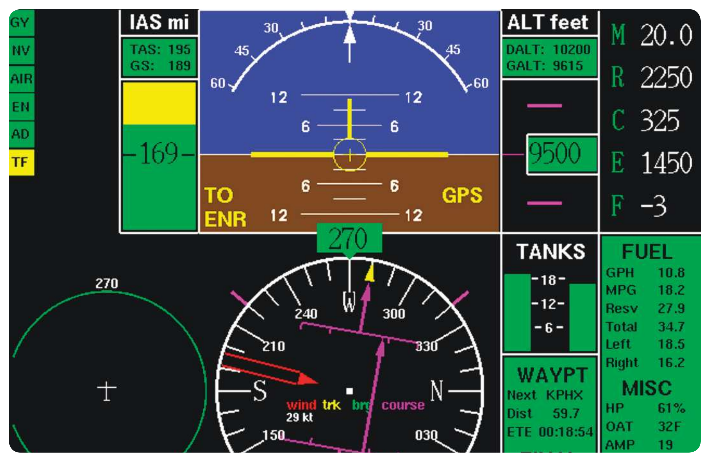
The two main panels are electrically connected with AMP CPC Series 1 connectors, and the Tygon air hose has lab-quality quick disconnects. The system is leak free. An additional plus is that the Tygon quick disconnects seal when separated, keeping contaminants out of the system.

Where the Rubber Hits the Road

For several reasons I was dissatisfied with the traditional panel scan and thought by rendering a single, primary screen properly it would minimize pilot workload. Basically, I imagined a "style" and rendered the screen to fit. This task would have been foolish without my pilot experience.

Buttons are another issue for my imagined style—the fewer, the better. If you begin with a small screen and have much more data than screen, you need many buttons; however, if you start with a big screen, then menu selections can be fewer. Pushing buttons to change screens in calm air is a disruption that becomes a major issue during turbulence.

All of these experiments were very successful, and I did create a very quick scan. It took many screen designs to get the organization, color usage, font size, and surrounding space right before my mind would quickly absorb the information. Every bit of information needed rationale to justify space on the primary screen.



I rendered the artificial horizon (AH) and the horizontal situation indicator (HSI) instruments much like their round equivalents because they are time-proven designs. Garmin 430W annunciators were added to the AH to closely couple navigation status during instrument approaches, and the HSI was the proper placement for turn rate and wind vector. The airspeed tape also shows true airspeed and ground speed, and the altitude tape also shows density altitude. The engine display is a summary but sufficient to set the engine controls. "C" is the highest cylinder temperature, "E" is the EGT average, and "F" is the flap setting. I originally rendered some cute dials to graphically show this information, but then I realized my eyes only focused on the numbers, ignoring the pointer. This is when cute becomes clutter, so I used the space for other information.

Fuel levels and accuracy are big issues for cross-country travel, and the RV-10 wing dihedral creates a problem. The top 8 gallons are above the float upper limit and invisible to panel calculations. After a bit of thought, I programmed the total fuel quantity value to show levels derived from flow data until the tank drops to 22 gallons; then I use the calibrated float values thereafter. This logic provided seamless instrumentation and maximizes accuracy as the fuel is depleted.

Cruising

A cross-country trip brings out the style of the pilot. I've watched myself and others perform the traditional scanning as we were taught, or simply watch the ground move along, or frantically push buttons to access every possible bit of information. I decided that my roll should be managing the flight, complete with delegating tasks. To help, I created a few metrics and priorities.

The metrics are: aircraft health, traffic, fuel, efficiency. Aircraft health is the highest priority and located at the upper left corner of the primary screen. Each box is multicolored and indicates the state of the components feeding data into the display computer. When the boxes are green and no flags have been raised, you are good to go.

The NavWorx ADS-B traffic area is located at the lower left and is large to indicate its value. Leader lines from each traffic position show its direction and speed. When the AD health box is green, then the system is receiving from an ADS-B ground station. As the traffic becomes closer, the rendering automatically escalates in decreasing ranges—12 nautical miles, 6 nautical miles, 2 nautical miles.

As a manager I want to know everything about fuel, but the most interesting metric is fuel at destination. After settling into cruise, this number is generally constant but varies slightly due to wind and routing changes. If it stays above reserve levels, we can make the next scheduled stop, and if it continues to drop we have a fuel leak. When filling up the tanks, the gallons added plus the fuel at destination number should be close to the total capacity.

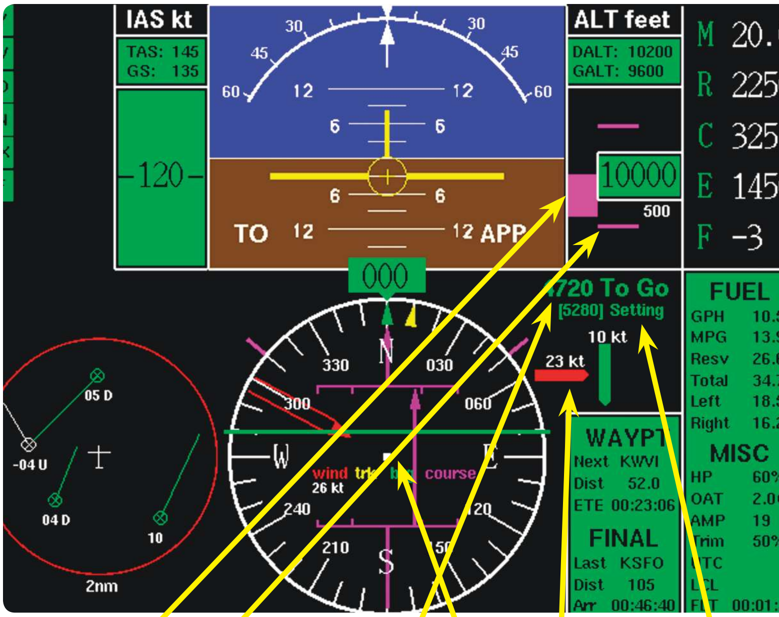
Efficiency is defined as statute miles per gallon, independent of wind. This creates a constant value that can be applied to any flight. From experience, when flying at 10,000 feet this number should be approximately 18; if it's much different I look around to find issues. There are many items that affect efficiency, such as atmospherics, load, balance, flap setting, mixture, power, etc. This is a simple metric to know all those items are optimum.

When leaning fuel, I watch all EGTs on my Grand Rapids engine monitor and show only the average EGT on my primary display to get a sense of the atmospherics. I have completely delegated the engine scan to the computerized engine monitor. If it detects a limit boundary, a big red light illuminates. A computer loves mindless, repetitive tasks, whereas my mind ignores gauges that don't normally change.

Instrument Approach Aids

Our mission includes IFR conditions, and I implemented graphics that help guide me along the localizer/glide slope down to the decision altitude (DA). To shift from cruise to approach mode I select the descent function on the ADC and key in the DA altitude as defined on the approach plate. The fuel balance graphic is overlaid with the vertical distance to the DA and wind components. I have gotten quite accustomed to descending using the vertical distance to the airport rather than continually doing the math. If you haven't guessed by now, I've replaced every mental calculation with automation.

Most approaches are a 3-degree slope, so I rendered the pitch ladder at 3-degree increments. I also use this angle for ascents and long descents to "professionalize" the flight profile for my passengers. The descent tick mark is a calculated value that represents a 3-degree descent rate. It's the standard rate of turn concept applied to the vertical axis. When the instantaneous rate drops to the tick, you are descending parallel to the glide slope. Then the correction becomes moving the plane up or down relative to the tick to center the glide slope. It is much



Rate of descent
Tick for descent at 3 degrees
Vertical distance to DA
DA value
Cross wind component
Glideslope and Localizer

easier than correcting the slope and vertical distance with one move.

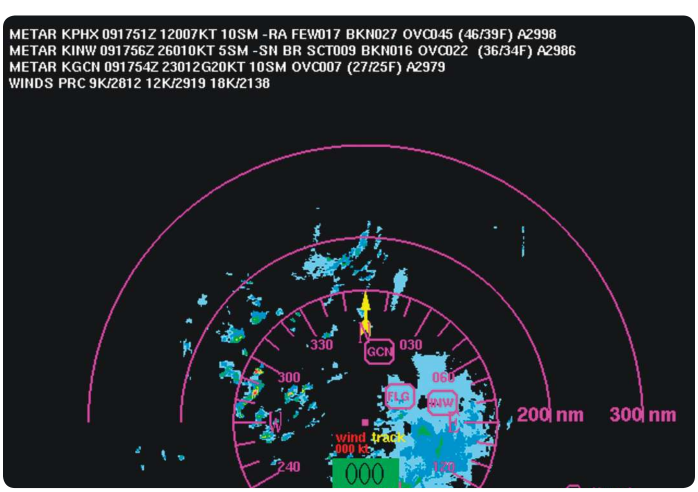
The wind components show why the airplane is drifting off the localizer, and a change in the crosswind component predicts where the plane is headed next. I can proactively react instead of finding out later that I have drifted off course. When approaching for a VFR landing, I still use the descent function and the airport elevation. The wind vector and component values help select the best runway miles from the airport and track the wind accurately down to the ground. The wind sock has become passé and not worth locating from above.

My Newest Best Friend

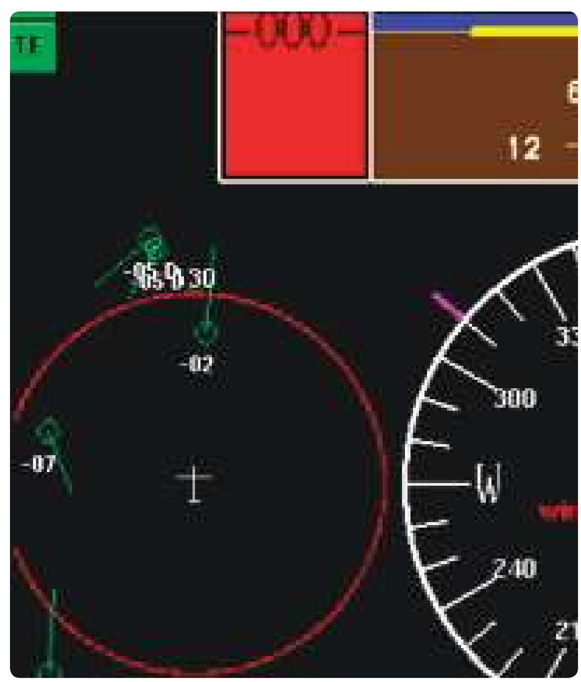
The ADC also selects the NavWorx ADS-B weather screens. I am normally flying on autopilot when looking at weather because these screens overlay the primary screen. The weather screens are: 360-degree view, airport Class B and C metars, 400-nautical-mile range forward, and 125-nautical-mile range forward. The 360-degree view shows the weather at all Class B and C airports surrounding my immediate location, and the following screen shows the metars at those airports. It is generally used early in the flight to plot a route around local weather.

A database of metars, winds, and temporary flight restrictions are built as the flight progresses. From this database, entries are automatically selected for display using the current route as retrieved from the 430W.

Below is the 400 nautical miles ADS-B weather screen that is optimized to look ahead of the aircraft with track-up. Metars are shown for the entire route, winds aloft in the nearest reporting area, and temporary flight restrictions are plotted and described. The purpose of this screen is to analyze weather along your route from where you are to your destination.



This is the ADS-B weather 125-nm screen looking ahead of the aircraft with track up. Many airports with their corresponding metars are shown in a 50-nm radius surrounding the next waypoint. Its purpose is to focus on the next waypoint or destination and provide options. Imagine fog is moving onshore and you need to find a clear airport. Since fog is invisible to Doppler radar, metars can be used to locate the fog line.



Without analysis

What You Can't See Can Kill You

You can control your pilot skill level, control your aircraft condition, even control known weather, but traffic is purely random. The big sky theory was only valid for the Wright brothers. I have flown for three decades looking for

With threat analysis

traffic visually and two years using ADS-B traffic; today I see five times more traffic using technology. It was always there, but it just blended into the background and was below, above, or behind me. FAA Flight Following has been a useful tool for our cross-country travels, but quality varies with the controller and the flight area. Flying in a barren desert can be more dangerous than terminal areas because vigilance varies dramatically.

I have found a significant problem using display graphics within a congested traffic area. My mind quickly becomes saturated because there are too many targets and they are traveling in three-dimensional space. To make it worse, I was staring at the display and creating more danger. I had to abort the electronics and look out the window. Of course, you always need to look out the window, but identifying which aircraft is trying to kill you first is a tremendous aid. To solve this problem I decided to let the display computer identify my primary threat.

When traffic is within 1.5 miles, another algorithm kicks in and calculates the closest point approach (CPA) for each target using 3D mathematics. Then, using time to CPA, it prioritizes the first and second threats. Magenta shows the highest, and yellow the second priority. "Spd" is the threat speed, "Min" is the calculated minimum distance between you and the threat at the CPA, and "Time" is seconds to CPA. The threats are updated every second so I can determine in real time whether the evasive action is improving or worsening my situation.

I have filed a patent that is now pending for this ADS-B threat analysis algorithm and the graphics.

At the End of the Day

Long gone and quickly forgotten are the vacuum system, unreliable spinning gyros, DG precession, and magnetic dip. Initially, I had not realized that replacing this old technology with solid-state gyros would necessarily lead to a glass panel, but it does. Today, our state-of-the-art experimental RV-10 has more functionality accompanied by more reliability than most certificated general aviation airplanes. Even with the many modifications, the backup system was only needed a few times, and no flight has ever been aborted due to equipment failure.

The distributed system design with independent backup system was a good, long-term strategy for several reasons:

- It handles equipment outages gently.
- It is almost vendor proof with Garmin being the only significant dependency.
- It can incrementally grow with technology enhancements without upsetting the core design.
- When a component breaks I can perhaps purchase the identical part or shop for something better or cheaper.

What if I was starting my panel today? Hard to say. Looking back, I sidestepped a lot of painful vendor issues. I like my backup system far better than purchasing glass components times two, and the stable round instruments are isolated from rapid glass panel technology developments.

It would be more expensive to build my system today than purchasing a box from current avionics vendors because many have developed less expensive gyros and build their own sunlight-rated displays. Gyros and displays are extremely expensive in small quantities.

Like Old Blue Eyes said, I did it my way. I've developed a great hobby intermeshed with my love of flying. Synergy and immediate gratification rolled into one. Few pilots realize their style of flying was mandated by the panel and instrument designer. What I slowly accomplished over the last six years was to analyze every uncomfortable flight situation and then implement computer aids until the panel perfectly fits my style. Safe and comfortable and fun.

I would like to thank Sara for her unwavering support. EAA

Bill DeRouchey, EAA 561449, was bitten with the flying bug while growing up around the airport in Long Beach, California. He received his pilot license in 1977 and instrument rating in 1992.

Build a Better Workbench

To build a better plane

By Cy Galley

With whatever you build, you need to check your work often. You need to check before you start chopping up expensive materials. Finding good procedures and information is much easier with great Internet access.

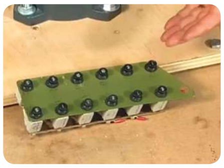
But there are other time-tested ways to get good information. One is the EAA Technical Counselor program. Our chapter supplements our technical counselors by letting everyone look at a project. It's rather simple; we pick a project and a date and invite all the chapter members to go to a member's home for a look-see, plus donuts and coffee.

We call it, what else, a "project review." The owner generally cleans his shop with everything put away and dusted. He also gets several prying eyes to check over his work and several suggestions to make it better, and perhaps someone will catch items that have been overlooked. Plus his shop is clean.

So what do those who come for the review get besides coffee, donuts, or maybe homemade cookies? The accompanying photo illustrates what I found at a recent project review—a good way to make a flat, straight, warp-proof workbench. A good workbench is an important foundation for building a straight wing, fuselage, aileron, or flap.

One could use wood, but it might change and warp with the weather. On the other hand, steel studs won't and are even plated so they don't rust. You need a single one-piece table as a foundation if you are building a Lancair IV, Falco, or a Monocoupe with its one-piece wing. This can be easily accommodated by using steel studding, which is available in 24-foot lengths in the 2 by 6 inch size. They are easily spliced for even longer lengths. Steel studs are commonly used to frame fireproof partitions. They are easily cut with aviation shears or a hacksaw and are fastened with drywall screws with no knots, lumps, or twists. Screw on a plywood top, and one has a lightweight workbench that is straight, rigid, and flat.

Hints for Homebuilders Videos



Installing Circuit Breakers

Dick and Bob Koehler show how to install circuit breakers for your panel. Dick and Bob are both Technical Counselors, A&P aircraft mechanics with Inspection Authorization (IA), and SportAir Workshop instructors.

Low Budget Hydroforming

Brian Carpenter of Rainbow Aviation shows us an alternate method for forming small sheet metal pieces that will be repeated numerous times, such as nose ribs for your metal wing.

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These drive gears, from a Rotax 582, were run for a short time without oil.

Engine Lubrication
A slippery topic

By Tim Kern

Our engines have many moving parts. Lubricants keep those parts from touching one another and carry their heat and contaminants away. The principles are simple. Nothing else is.

Design engineers, when they draw up engine systems, have lubricants already in mind. They know, for instance, which materials to use, how close to make the clearances, and how loose to make the tolerances. Knowing the lubricants' properties, they design the most robust system they can. Improve the lubricants, and the game changes. ExxonMobil Aviation Lubricants Product Advisor Dr. Shlomo Antika put it simply: "What oil engineers do is create molecules that get between the moving metal parts."

Once these engines (and gearboxes and water pumps etc.) get into our hands, we are expected to meet the designer's expectations, providing the right kinds, quantities, and temperatures of the proper clean lubricants.

As an example, in a typical engine, oil is introduced under pressure into one area through holes in the main bearing saddles. This oil keeps the crankshaft and the main bearing from touching and welding themselves together. The crankshaft has holes in it, through which the main bearing oil gets transferred inside the crank to the rod bearings, where it keeps these bearings from welding themselves to the crankshaft. The oil then escapes into the crankcase as splash and mist, where it lubricates the cylinder walls, some valve train components, and piston pin; and it puts its protective coat on all the engine's internals. Then it flows downhill and gets collected in the sump, goes to the oil filter and pump, possibly to a de-aerator and cooler, and back out to the bearings again.

What Happens as This Happens

The high-pressure oil from the pump should be a bubble-free, contaminant-free stream of oil. Modern lubricants are "long-string" molecules, containing the base petroleum stock and additives to enhance cleaning and wear, and to contain and fight contaminants such as metal, carbon, and water. As the oil is used, these molecules are literally torn apart; long-string molecules get chopped up; the oil wears out. Dr. Antika said that's not a hugely significant problem. "Viscosity loss is not typically a concern. The polymeric viscosity-improver molecules break down to some extent by shear and heat, but multigrades (certainly ours), stay [within] SAE grade during use."

Much worse is contamination. Water occurs naturally through condensation. Water in oil is bad. Water is not a good lubricant. If the engine is run often enough at a high enough temperature, most "suspended" water boils off; some, though, stays as "dissolved" water and remains in the oil.

The molecule—H2O—is short. This is one reason why plain water is not good in liquid cooling systems. Yes, it freezes; but even in temperate climates, and even though water's ability to absorb heat is unparalleled, it can't lubricate the water pump! Worse, water displaces oil, forcing the good lubricant out the breather and reducing the amount of lubrication available in the engine. Further, that suspended water sits on the metal surfaces, encouraging corrosion. "Additives help keep the suspended water off the metal," Dr. Antika said. Here's how: "The polar heads tend to accumulate on the metal surface; the (oily) tails repel the water." Okay, good.

Carbon contamination (also bad) occurs through combustion and is blown at high temperature and pressure past the piston rings, where it is washed by the crankcase oil to the sump to be soon captured in the oil filter. Carbon is particularly abrasive, and once the rings get to a certain point in their lives and can no longer keep the combustion fully above the piston, oil filters get quickly overwhelmed and engine wear is rapid. (Hence, the periodic leakdown test.)

Metal belongs where it started, but various metals are routinely and unavoidably scraped off various moving parts: steel from rings; lead, copper, antimony, and various semi-exotics from bearings; aluminum from pistons; bronze from valve guides; iron from cylinder liners—it's all in there, in varying quantities and proportions. Routine wear is predictable and unavoidable; nothing lasts forever. What we want to do is to maximize the length of this life cycle, and know if some particular wear is unexpected.
When an engine is new, it is normal for the new parts to scuff each other a bit. (And as Dr. Antika noted, "Some engines are so old, they depend on deposits to keep from leaking.") As an engine "breaks in," wear declines to its operational minimum. As the engine ages, carbon and the cumulative effects of water (corrosion) and the engine's mission characteristics take over, and wear accelerates until the engine needs an overhaul.

Interestingly, some good work (such as a top-end overhaul that increases compression) can escalate other wear (such as on the main and rod bearings). Rebuilding the bottom end but not the top doesn't put more stress on the top end, but this is not a normal sequence of rebuild.

Regular oil analysis tracks specific contaminants and can help identify when any one of them gets off track. Likewise, the engine's oil filter should be cut open and examined at every change. When you see something there that's not "normal," it's time to find out what and why.

A rebuilt, remanufactured, or overhauled engine, by the way, should generally be treated as a new engine. Use the recommended break-in oils and procedures; but beware… that first oil change may scare you. For instance, a new Rotax 912 is assembled with black (molybdenum) grease; your first oil will look like it came from a diesel. Bill Middlebrook, master rebuilder and president of Penn Yan Aero, noted, "Especially in overhauled engines, you may find silicone, glass or plastic beads from blasting, red threads from shop rags…" After one or two oil changes, that should cease. (For the record, Penn Yan doesn't bead blast or use silicone sealants in its rebuilds.)

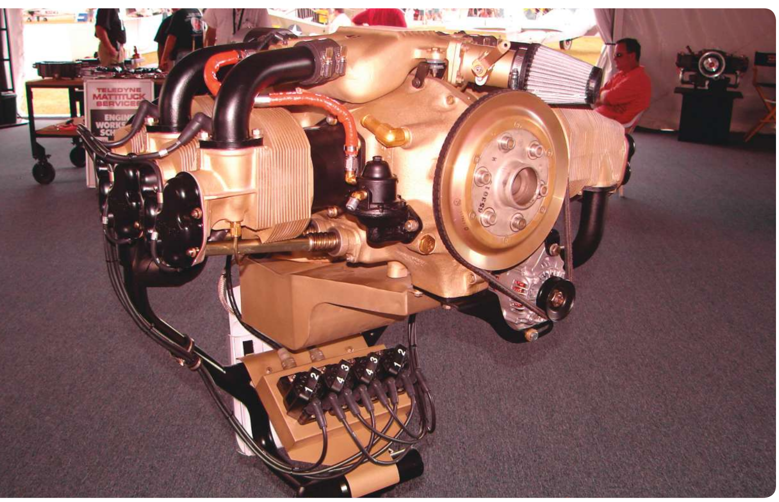
Each Component Is Critical

The oil filter is effective and inexpensive. It captures particulates and even some water, but it won't do a thing to

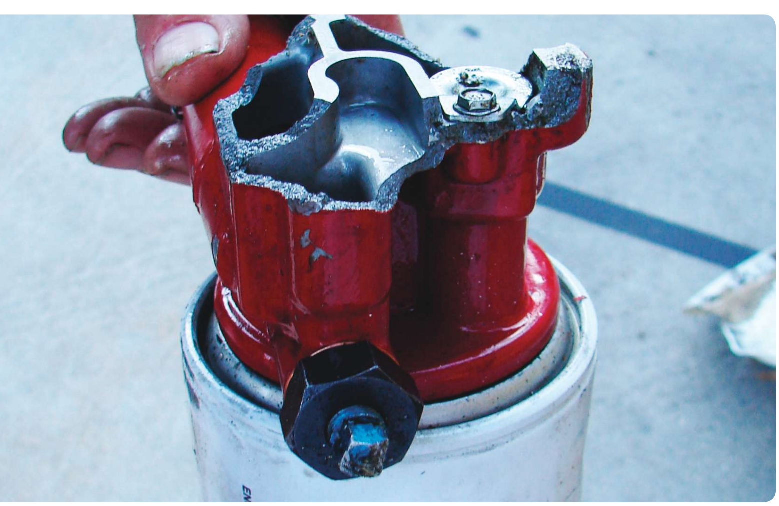
The rod bearings are lubricated directly through the main bearings, and by splash; but this one wasn't.

remove, say, gasoline that gets into the oil from overpriming. Change the filter often, ideally every time you change oil, which should be at least as frequently as the manufacturer recommends (by both hours and calendar; water accumulates even when the Hobbs meter isn't running).

Don't use automotive filters on airplane engines. In 2008, I wrote that Steve Staudt of Champion Aerospace emphasized that oil serves a dual purpose: lubrication *and* cooling. "Since [Continentals] and Lycomings are air cooled, they flow a tremendous amount of oil through the lubrication system, hence through the filter." Oil is essential to proper cooling. For comparison, "A liquid-cooled automotive engine may only see one gallon a minute oil flow through its spin-on filter; [but] a 6-cylinder [aero] engine can see as much as 20 gallons per minute oil flow through the filter at takeoff. (Gallons, not quarts!) You begin to



The large sump on this conceptual Continental O-200 collects, de-aerates, and even cools the oil. (Note that there are no cooling fins on the cylinders.)



If any component in the oil system fails, you won't get oil. This is a rather catastrophic failure, the kind of thing that happens at Reno. It shouldn't happen on your engine.

understand why small, downsized automotive filters don't work on aircraft."

An engine's bearings are made of softer material than what they protect. Most aviation engines have replacement bearings for high-wear items such as the main and rod bearings, and the camshaft (though the Rotax 912 runs the cam directly in the case—another reason to make sure the oil system is up to snuff). These relatively thick, relatively soft bearings do more than cushion the shocks of combustion and inertia; they also allow tiny fragments of abrasives to embed themselves, keeping them from doing extensive damage. Further, they are more porous than the metals they protect and thus "hold" lubricant in place.

Oil that collects at the bottom of the engine system has been through tough times. It's been squeezed, sheared, smashed, splashed, heated, aerated, and contaminated. All of which are bad. For the oil filter to do its work, it needs oil, not air. Though air tends to bubble out naturally, many systems incorporate a specific stage to de-aerate oil; the remote oil tank on dry-sump systems separates liquid and gas.

The oil cooler's purpose is obvious, but it is important to make sure that air cannot accumulate here, either. Always position the outlet at the top end of the cooler. Give air bubbles a route to escape.

The rest of the system is equally critical. If the oil pump stops, so will your engine. If the oil pickup tube gets blocked or falls off, your pump won't get oil. Oil lines are easy to burn, damage, or crush. They're relatively inexpensive; inspect them frequently, and don't be cheap about changing suspicious ones.

A note, particularly on oil coolers and lines, but especially so for other elements in the oil system, such as crankshafts: Your shop parts cleaning tank is a terrible thing to use on these components. In its sump are all sorts of evil particulates, which easily pass through the best parts-tank filters. When you need to clean your oil lines or cooler, don't use your parts tank, even if you've just changed the fluid and filter. Proper aviation shops or speed shops (that do race crankshaft work) usually have a proper cleaning regimen.

If your engine somehow ruins itself, throw away the oil cooler, oil lines, and anything else that you can. Have the remaining parts cleaned by a facility that truly knows how.

What about oil heaters? In cold climates, they allow the engine to start, but in general (and there are some exceptions) they shouldn't stay on all the time, as they're not hot enough to boil out the water, and corrosion, of course, ac-

Use the lubricants that are recommended by the manufacturer. This Sadler Vampire's Rotamax is placarded against synthetic lubricants.

celerates with elevated temperature. Use a preheater only when you plan to use the engine.

Which Oil Should You Use?

Do what the manufacturers say. They know what their engines like. Don't try to make cheap oil into good oil by adding additives; the good oil purveyors already came up with the right mix. Air BP's John Copper once told me that the topic of additives "…is mired in misinformation, dubious science. If there is an additive that is good, it is known by and available to the formulator." Remember, too much of a good thing is a bad thing. Copper added, "For every drop of additive put in, a drop of the actual oil is removed."

Use the best oil you can afford, and remember that oil is less expensive to buy and replace than any other component of your engine.

Also, don't assume just because one manufacturer recommends a particular oil that another manufacturer's engine will like it. What's perfect for a Rotax won't be perfect in a Continental. If you are running an auto conversion, join the users group and find out what the majority of people are using and what success they're having with it. (And don't assume that the loudest guy in the group is always the smartest guy.)

In a 2005 article, I noted that Roy Howell, an engineer with Red Line Synthetic Oil, explained another big difference between aero engines and auto engines. He said modern car engines (and close-tolerance engines such as the Rotax) have parts that are so close together that their lubrication is on the molecular level. Traditional aero engines, because of their huge surfaces, also have enough room between moving parts that a hydrodynamic layer of oil film exists between the two boundary layers. In effect, one part has its layer of molecular protection; then there's a film of oil; then there is the other part, with its own boundary layer. It's a higher-friction environment because of the relatively huge areas of oil that get pushed around; but it's also a low-wear arrangement, since so many stresses are spread over relatively huge areas.

The happy news is that frequent, long flights can extend oil and engine life.

One last note: No properly broken-in engine ever was damaged by too-frequent oil and filter changes! EAA

More information is available on these websites:
www.ExxonElite.com
www.AirBP.com
www.AeroShell.com
www.Rotax-Owner.com
www.PennYanAero.com
www.ChampionAerospace.com/products/oilfilters
www.SAE.org/technical/standards/ARP1400B.

Tim Kern is a private pilot and has written for more than 40 different aviation magazines. He was a key builder on two aircraft projects and has earned the title of certified aviation manager from the NBAA.

Rusty bolt shows the effect of not sealing holes in wood spars on a Bowers Fly Baby built in the early 1960s.

Corrosion and Foreign Materials

Their effect on aircraft

By Chuck Burtch

Aircraft construction uses many materials that sometimes are not compatible. The materials are chosen for their strength and manufacturing properties, and engineers typically consider their application as to the stress applied and how the part is to be made. Corrosion is generally a secondary consideration and is frequently handled by other methods. For example, when dissimilar metals attach to each other, some kind of barrier is used.

Let me start by stating that this article is written on a mechanic's level and is based on my experiences as a U.S. Navy mechanic, my restoration of several aircraft, and my construction of an amateur-built aircraft. My day job was that of a wood patternmaker, primarily in the centrifugal pump industry. It was my job for some 35 years, so I know my way around a wood shop pretty well. My experience with wood in aircraft is mostly in wood wing construction. While these remarks are mostly generic in nature and represent good practice in my experience, I must emphasize that if you are working with a certificated airplane, you should *always* adhere to the manufacturer's recommendations for service and repair. Similarly, with a homebuilt, *always* follow the manufacturer's instructions for construction practices, service, and repair.

If the observations in this article disagree with what the manufacturer's instructions say, go with the manufacturer, but this should give inspiration to start a conversation about those practices. In the pattern manufacturing industry, we commonly would lubricate our saw, jointer, and thickness planer tables with paraffin. It allowed our lumber to slide almost effortlessly across these tables. Some folks often wax these tables simply for corrosion protection. It is also common practice in cabinet shops to oil machined surfaces for corrosion protection. Keep in mind that if you mill or saw aircraft wood parts with waxed equipment, you risk contaminating the wood with the wax or oil, and the result might be bad glue joints. These surfaces must be clean and free of any wax, oil or paraffin. This includes the thickness planer rollers.

When building with wood, there should always be a barrier between wood and metal parts. Most builders use epoxy varnish on wood and epoxy primer on steel parts. Aluminum parts also can be primed, but this is not always done due to modern aluminum's corrosion resistance. The most common violation is drilling holes through wood for steel bolts. That nice new Sitka spruce will cause bolts to rust if the holes are not sealed. Some varnish and a pipe cleaner work well, but beware of excess varnish in the holes. A reamer sized for the hole may be used to clean out small amounts of varnish from a hole in wood structures. Turn the reamer by hand, and try to do this at a time when the varnish is not fully hard. Remember, you do not want to remove wood, and hard epoxy varnish may be harder than spruce or plywood. If the varnish is in a softer state, the reamer will tend to follow the existing hole. Tape and small, locking pliers work well as a handle. Clean the reamer and wipe it dry after each hole as it will fill with varnish.

Another method is to assemble the fittings and then install the bolts with wet varnish. I have done this with conventional spar varnish and have had good results. I'm reluctant to use epoxy varnish here as it just might glue the bolts in place. Regular spar varnish is fine in drilled wood holes as a sealer. Remember that it is not dope proof, which is one reason we use epoxy anywhere fabric is to be applied. The epoxy is dope proof, a luxury early mechanics didn't enjoy. The wet varnish method is somewhat messy but is very effective. As a rule, epoxy varnish is preferred in all other phases. Use cadmium-plated AN hardware and you should be fine. Be sure to pre-varnish under plate fittings and let them dry prior to assembly.

There is plenty of data on wood rot and drain holes, and since it is not my topic I won't go into that here. One last point on wood, though, is about the leaking of fuel and oil. If there's a spill, make sure it is completely cleaned up. Fuel- or oil-soaked wood structures will quickly break down and delaminate.

Tubular Steel

On tubular steel construction, light oil can be used to prevent rust during construction. Do not use a silicone-based oil as it offers little rust protection, a common mistake. Do not use too much oil; wipe off the area with a clean dry cotton cloth before welding. Once the welding is

This plate is from a 1946 Aeronca Champ and shows very little rust because of a good coat of primer.

A drill bit sized for the rivet to be driven. A plastic syringe like this can be used to inject preservative oil in the hole. Using a syringe is an easy way to measure the proper amount of oil to seal the hole.

A driven rivet is started and tapped in with a small hammer.

completed, a fine sandblasting and epoxy primer will work well. Remember that all oil must be removed in order to sandblast. You cannot sandblast over oil as the sand will not remove the oil and will cake up.

Lacquer thinner or an appropriate solvent also works fine, but use gloves and work in a ventilated area. Let everything dry completely prior to sandblasting. The sandblasting should be done on clean, dry steel and should be free of any substance after completion. Once blasted the part must be handled with clean gloves. The natural oils on your skin contain salt and will quickly cause rusty fingerprints. Remember that aircraft manufacturers building airplanes with steel tube fuselages seldom sandblasted the parts. They were generally built very quickly, wiped down with a cleaner, and primed. In 1940, these manufacturers used a zinc chromate primer and then only a thin coating was used.

Amateur-built parts are constructed over a longer period of time and may require sandblasting. Fine sand should be used so the peaks between the sand pecks do not stick through the primer. Glass beads or soda blasting are other possible methods. Do some research if you are sandblasting, as you can destroy something that took you a long time to build. For example, a large industrial sandblaster can actually cut through a tubular structure in a very short time. Some auto restoration shops do nice work with sandblasting. Their goals are similar to aviation folks with delicate parts and high quality. Check around if you hire out sandblasting. Remember, you're building an aircraft, not a bridge.

Line oil or "tube seal" may be used on the inside of tubular structures and is optional. I have sawed up old fuselages with airtight welds and found no rust. Open-end tubing such as a strut should be oiled. Some line oils are progressive, meaning they will creep above the oil level to coat the whole piece of tubing. Some wise old mechanics will drill a small hole inside a longeron cluster. Then line oil can be injected in the longeron and run through the holes into the diagonals. Since the cluster weld surrounds the holes, there is no strength penalty. (See photo reference in *Sportplane Construction Techniques* by Tony Bingelis, pages 66 and 70.)

This practice also allows a pressure relief during the welding process. You can buy a plastic oiler and oil through a very small hole. AN driven rivets can be used to plug the holes and are driven in with a small hammer. An alternative is a self-tapping screw. I do not recommend plugging a 1/8-inch hole with a pop rivet. Such a hole is much too large and the rivet is not airtight. Ask the plans or kit vender before drilling any holes in the primary structure. Follow the instructions for the use of line oil to the letter. One last warning is that some line oils are boiled linseed oil and are very likely to spontaneously combust on a rag. I know of a massive hangar fire caused by linseed-oil–soaked rags thrown in a plastic trash can.

Sheet Metal Construction

Sheet metal construction can have all sorts of problems with corrosion and foreign materials. One of the most common is dissimilar metal corrosion or galvanic corrosion. If bare, dissimilar metals are in contact, the different electrical values can cause corrosion in the presence of moisture. One example is steel and aluminum, but it can happen with different aluminum alloys as well. Using a primer or paint barrier between these parts is a common practice. Powder coating also has been used on both steel and aluminum, but it is not recommended in aircraft structure for a number of reasons. It looks nice and can be really hard shell coating, but it also hides cracks, particularly on engine mounts. It's quite possible for the tubing to crack and the powder coating to remain intact. This being said, it is used; I'm just not fond of it.

When building with wood, there should always be a barrier between wood and metal parts. Most builders use epoxy varnish on wood and epoxy primer on steel parts.

The use of cadmium-plated aircraft hardware on aluminum structures is commonplace. The cadmium acts as a barrier between the steel hardware and the aluminum, a classic location for galvanic corrosion. Cadmium is not only a dissimilar metal barrier but a sacrificial metal to help prevent corrosion of the part. A cadmium-plated fastener can easily be replaced when the cadmium corrodes and thus allows longevity of the aircraft part. Some builders install hardware with wet primer much like bolts in wood structures. Also, the simple turning or tapping of a bolt in tightly reamed holes can wear through the cadmium plating. The final bolts and screws installed should be new.

Another problem with aluminum airplanes is simply washing with the wrong soap or cleaner. Remember that dishwashing detergents usually contain citric acid that will wick into lapped joints and start corrosion. Use an aircraft soap or cleaner and rinse thoroughly. Some spray cleaner products admonish users to rinse thoroughly. Only spray cleaners marked for aircraft should be used; do not use common household cleaners. If you read the fine print, you may be surprised to find that many household cleaning products say, "Do not use on aluminum."

Sometimes preservatives can be used. These should always be applied to clean areas; they can be applied by spray or brush. They are typically used in areas subject to wheel spray and other lower areas on a plane where debris settles—basically the bilge areas of your aircraft. Paraketone (pronounced "parrah key tone") can be used; it is a semi-dry amber liquid. I have applied it to wheel wells, strut housings, and speed brake wells on F-4 Phantom aircraft. It can periodically be cleaned off and replaced as it can attract dirt. Paraketone never really fully dries. We used it on our F-4s based on an aircraft carrier in a sea salt environment. Aircraft based at airports along the coastline also can have salt corrosion problems and may require more frequent washing and paint touch-ups than those in "dry" areas.

Other corrosion problems on aluminum structures include exhaust trails and vomit. Exhaust residue is very corrosive and requires frequent cleaning and paint work. I personally know of a Piper Cherokee in which this is a continuous task, downstream of the exhaust. Also, if someone gets air sick, make sure it is all cleaned up. Vomit is very corrosive and not a great smell on a hot day. Carry sick sacks!

Finally, battery boxes are another big problem with lead acid batteries. Keep everything clean, and use the special paint where required. Modern recombinant-gas dry-cell batteries are wonderful pieces of technology, but if the installation calls for a flooded (wet-cell) battery, make certain that the battery box is properly sealed, properly coated, and that the vents are clear. The box itself is not the only concern. The area under and around the box as well as both the interior and exterior areas around and downstream of the vents are typical locations that require special attention with regard to corrosion.

Things to Remember

- Never use brake cleaner on anything that is to be welded. It will produce phosgene gas which can kill or permanently harm you.
- Use proper safety equipment when spraying primers, preservatives, or varnishes.
- If using MEK (methyl ethyl ketone) or another solvent, follow the safety instructions and never use it with your bare hands. And use in ventilated areas only!
- Never use cadmium-plated hardware or tools on titanium parts.
- Beware of walking on ice melt and then entering the cockpit. Keep some flying shoes. The salt can be corrosive to the interior.
- Beware of sandblasting with recycled or recovery sand that has been used on different metals, for example, stainless steel and carbon steel.

I hope these comments help with the construction or restoration of your aircraft project. A little planning and preventive maintenance can give you many years of enjoyable flying without compromising the construction with time-delayed corrosion.

Always be vigilant of materials or corrosives that can harm your aircraft. I have only touched on the basics of this topic. A wealth of in-depth data is available through all kinds of EAA, military, and FAA manuals. EAA

Chuck Burtch, EAA 10213, has built and restored a variety of aircraft and is a long-time member of the EAA Air Academy staff. He is also an active EAA technical counselor.

These photos show vent holes drilled in longerons and diagonals as they would form a cluster over the vent holes. Holes allow both venting and oil flow.

Photography by Robert Quick

GE 1.6MW turbines of the Pioneer Trail Wind Farm near Paxton, Illinois.

Wind Turbines and Light Aircraft

A tricky combination

By Dan Grunloh

The United States had 45,100 wind turbines in place as of December 2012 according to the American Wind Energy Association, and we are expected to add about 1,000 more large turbines per year for the next five years. About 3.5 percent of U.S. electricity comes from wind, and some experts predict that number could easily double. The Wind Energy Association's long-term goal of 20 percent from wind seems a long way off, though five states are above 10 percent, and two states, Iowa and North Dakota, already get more than 20 percent of their electricity from wind. Wind turbines may help to diversify our energy sources, but they are a hazard to aviation. They can prevent you from flying or even close down your airport.

The U.S. Department of Energy provides an 80-meter-high wind resource map for the United States, with links to individual state wind maps. Any area with more than a 6.5 m/s (14.5 mph) annual average wind speed may have potential for wind energy development. The western states have plenty of wind, but vast areas lack sufficient electric grid for wider distribution. Texas and California are our top producers, but states in the upper Midwest including Illinois, Iowa, and Minnesota are gaining rapidly. The area of red coloration on the wind map located in northwest Indiana and northeast Illinois (where I live) is the primary area east of the Mississippi suitable for large-scale wind farms. They are popping up here as fast as they can be erected.

While flying in a gentle circle at 2,000 feet over my home airport near Paxton, Illinois (1C1) recently, a total of four wind farms can be seen. Three are on the horizon, and one is directly below. Two more are planned nearby. A check of the Chicago aviation sectional reveals wind farms scattered from Bloomington, Illinois, to Lafayette, Indiana. This 100-mile long swath just south of the Chicago area could someday be nearly continuous wind farms. At the eastern end, the Kentland, Indiana airport has struggled to keep wind turbines from encroaching into the airport area and impacting the instrument approach. The FAA must be notified whenever a wind turbine is to be built within five miles of a public airport.

Left Is Best

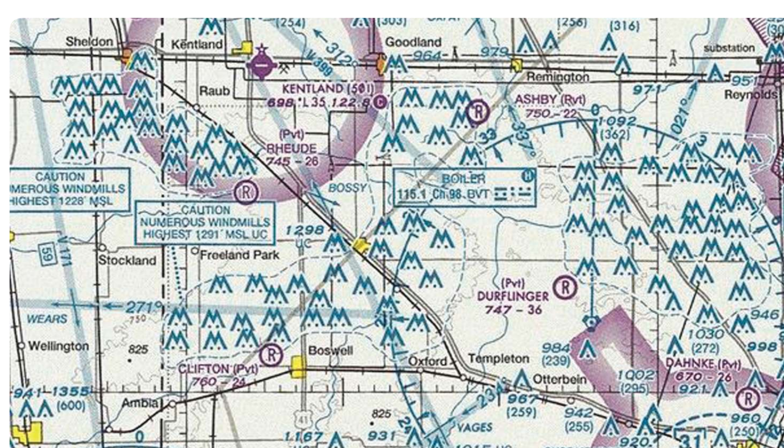
As pilots we are trained to take note of wind indicators such as smoke, flags, and waves on the water; but now we can add wind turbines. All wind turbines turn the same direction, which is clockwise or right-hand rotation when facing the hub with your back to the wind. Positioned behind the turbine and facing into the wind, the rotation will always be to the left. Left is best for takeoff and landings. The predominant takeoff direction at my home field features 400-foot turbines in the windscreen, so I have added them as a final takeoff check. I even made up my own mnemonic, "Left—back. Right—on. Turning left equals being held back (by the headwind), and turning right means you go right on and dash your airplane onto the over-run fence.

I've been flying for almost two years near, over, and around the 94 turbines at the Pioneer Trail Wind Farm near Paxton, Illinois, and can offer a few observations. Flying near the turbines when they are stationary is a bit like flying through a scattered forest of giant redwood trees. Flying near the 400- to 500-foot-tall turbines when they are spinning is more like canyon flying with the walls waving at you. It can be difficult to judge your distance from them because they are so large, and we have little experience with such obstacles. The typical blade diameter is either 80 meters (270 feet) or 100 meters (328 feet). Mast height is also 80 or 100 meters. With a rated top speed of about 18 rpm, the blade tips could be moving nearly 200 mph. The FAA requires aircraft to maintain a 500-foot clearance from obstacles, so keeping your airplane at least two rotor diameters away from the outstretched turbine tips is a good guide.

Simple arithmetic shows it is not possible to legally fly between two wind turbines unless they are more than 1,300 feet or a quarter mile apart (measured from tower to tower). To understand why this is important, look at Google Earth or another satellite view of Paxton, Illinois, or Kentland, Indiana. The turbines can be seen easily on the grid of roads that are typically spaced one mile apart. Wind turbines are placed anywhere from three to seven diameters apart, so some areas must be avoided entirely when the cloud ceiling is low and you cannot fly over them. It's not so simple when your private airstrip is near or within the wind farm. Incidentally, ultralights flying under FAR Part 103 rules have a different clearance standard (hazard to persons or property), but flying much closer than 500 feet to moving rotor blades could be seen as reckless behavior, which is also prohibited.

Flying near the turbines when they are stationary is a bit like flying through a scattered forest of giant redwood trees.

Dan Grunloh with his Air Creation racer after wind turbine photo flight.



The sectional chart for the Kentland, Indiana, area showing numerous wind farms.

If you have wondered how crop dusters deal with wind turbines, check out this YouTube slide show of Illinois pilot Bobby Baker at work among the turbines.

Low Ceilings and Bad Weather

Wind turbines can prevent you from flying when the cloud ceiling is low because they raise the minimum altitude required to clear obstacles by as much as 500 feet. Airports with limited access because of controlled airspace or terrain will be inaccessible more days per year if you place a forest of 500-foot obstacles on the approach route. For turbines placed close enough together to constitute a congested area, regulations and common sense require 1,000 feet over the highest obstacle. Additionally, the clouds must be another 500 feet higher because you will have moved into Class E airspace and need to be 500 feet below the clouds. A cluster of 500-foot wind turbines could increase the minimum ceiling for VFR flight to 2,000 feet in that area. Fly around them if you can.

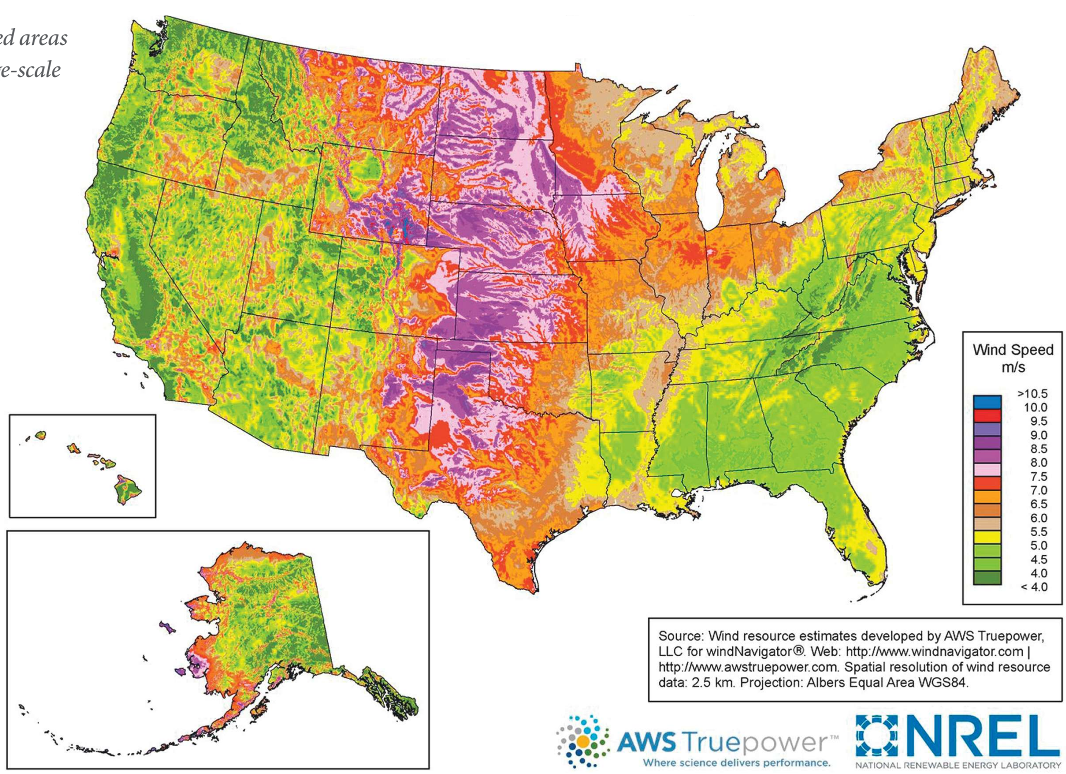
The growth of wind farms can make a dangerous activity like scud-running even more treacherous. Sport pilots must maintain three miles of visibility at all times (even in Class G airspace) whereas ultralight pilots and private pilots may fly in only one mile visibility when down low among the turbines. I have driven through the

The growth of wind farms can make a dangerous activity like scud-running even more treacherous.

local wind farm on the country roads during marginal VFR conditions with dark clouds, light rain, and mist. Those white towers and turbine blades turn dark and blend in very well with the gray sky. Sometimes turbines are up and running before they show up on sectionals. Sometimes the red warning light on the tower is not functioning. Among the several wind farms in my flying range, there are always a few turbines that are not lighted. Blundering into a wind farm in light rain while scud-running could ruin your day.

Turbulence Not a Problem

It's natural for pilots of light aircraft to be curious about wake turbulence downwind of the spinning turbines. Is it safe to fly in their wake? Will a cluster of turbines diminish the average wind enough to affect aircraft landings and takeoffs downwind of the wind farm? Visual indications such as the photo of cloud plumes generated at the Horns Rev offshore wind farm, west of Denmark (published here by NOAA), led some investigators to conclude turbine wake turbulence could be a threat to



Red and blue shaded areas are suitable for large-scale wind development.

Horns Rev offshore wind farm, west of Denmark.

aviation. It was a serious enough concern that a German energy company commissioned a scientific study for a wind farm planned near a microlight airfield near Boslar, Germany. The research news website *Science Daily* reported the results in its "Wind Farms: A Danger to Ultra-light Aircraft?" article. A sophisticated computer model predicted the turbulence would be no different than the natural background turbulence, whatever that means. Field measurements downwind of turbines were said to confirm their computer model. More convincing are real-world reports by local pilots and friends who have deliberately flown ultralights or light planes in the turbine wake. No unusual turbulence was found. All agreed mechanical turbulence from ground objects like buildings or trees was stronger than any bumps found in the turbine wake. One ultralight pilot suggested the turbulence may actually be greater when the turbine blades are stationary! By making careful tests in very smooth stable air with my single-seat trike, I was able to identify very light bumps located just where you would expect wingtip vortices. They would bother only the lightest ultralights and only if landing close behind the wind turbine.

Airports at Risk

Wind turbine farms are a threat to both public and private airports because of the money involved. Some public airports have already been threatened with closure simply because their presence interferes with a proposed wind farm. The average small town airport is not a major source of revenue and may actually be an expense to the city or county that owns it. Wind farm development can bring hundreds of thousands of dollars annually to the local school district in property taxes and provide royalty payments to landowners of $7,000 to $9,000 per turbine.

Developers understand they need to maintain good relations with landowners and will adjust turbine locations to accommodate owners needs, including those with established private restricted landing areas. Unmarked, unrecognized private ultralight airstrips are more vulnerable. One wind turbine off the end of your runway will put your neighbor's kid through college. EAA

» Please send your comments and suggestions to dgrunloh@illicom.net.

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

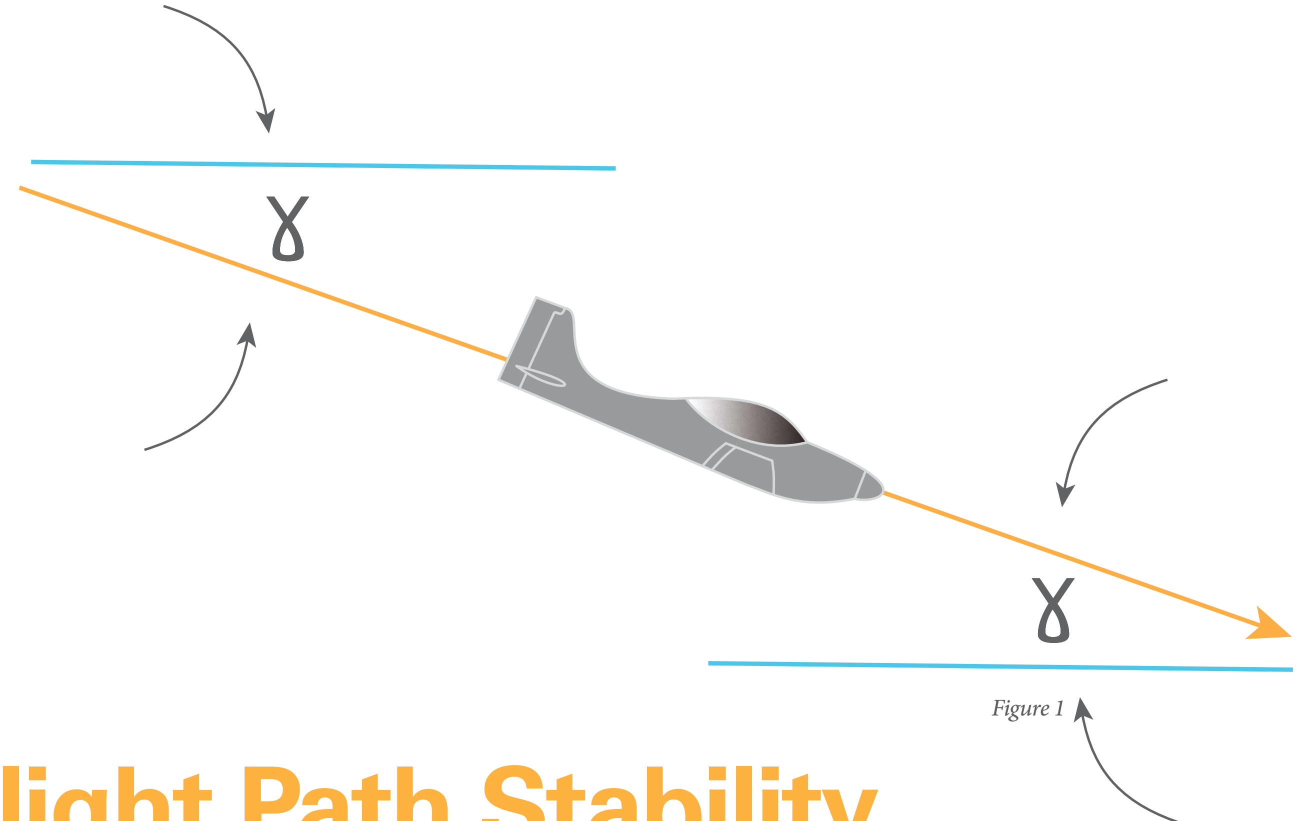


Figure 1

Flight Path Stability Test Technique

Creating the stability curve

By Ed Kolano

Last month we introduced flight path stability, or how airspeed changes affect your airplane's vertical flight path. We described the intuitive expectations when flying on the front side of the flight path stability curve—and the perception danger of the back side. We completed our discussion by looking at different flight path stability curve shapes and how they influence the way we control glide path during final approach.

This month we will describe the flight testing that will let you gather the data you need to create your airplane's flight path stability curve. The flight test procedure is straightforward; but it can be demanding because you'll have to keep your airspeed within just one or two knots of the test speeds to acquire meaningful data. Demanding, but it's certainly doable in smooth air. With a little practice, you'll collect the data you need in short order.

The test philosophy is simple. We want to know how changing airspeed on final approach affects your airplane's descent angle. Because your plane probably doesn't have a descent angle indicator, you'll measure its forward speed and vertical speed. Then, after a little math fun…voilà…you'll have the vertical flight path angle (γ, pronounced "gamma"; see Figure 1). We'll do this for a range of discreet airspeeds, then literally connect the dots to create the flight path stability curve.

Flight path stability information is most useful for final approach, so you'll probably want to perform the test with landing gear, flaps, cowl flaps, etc. set as they'll be on final. You can perform this test in any configuration you like, but the results will apply only to that configuration.

In addition to keeping the plane's external configuration constant throughout the testing, we're going to leave the power controls (throttle, prop, and mixture) at one setting. Setting the controls for sufficient power for level flight at your typical final approach airspeed is a good place to start. If you normally fly power-off approaches, you can test that way, but it will take longer, as you'll soon read.

Here's the basic idea. You're going to record airspeed and descent (or climb) rate at several airspeeds. How many test points you record is up to you, but more data will give you better results. You'll want to map the range of airspeeds faster and slower than your final approach speed. For example, if 75 knots is the proper approach speed and your plane stalls at 60 knots and its maximum gear-down speed is 100 knots, you might target eight airspeeds at 5-knot increments between 65 and 100.

Nuts and Bolts

At a safe altitude, establish level flight and trim for hands-off flight. Note the observed airspeed (what you read on your airspeed indicator) and outside air temperature (OAT) because you'll use these to calculate your true airspeed after the flight. You'll also need your pressure altitude for this calculation, so set your altimeter to 29.92.

Here's the basic idea. You're going to record airspeed and descent (or climb) rate at several airspeeds. How many test points you record is up to you, but more data will give you better results.

Using only back stick, slow down a few knots. Your first target speed is 70 knots, but you can accept a couple of knots faster or slower. You don't have to be exactly on speed here, because you're going to record data over a range of airspeeds and draw a curve to fill in the airspeeds you don't test. Just make sure you maintain whatever speed you pick within +/-1 knot and the spacing between test points—i.e., the difference between the airspeeds where you record the data—is reasonably consistent.

At this new, slower airspeed you'll probably be climbing. That's okay. Stabilize your airplane at the new airspeed. Your plane will be stabilized at the test condition when its airspeed needle is rock steady, your pitch attitude is unwavering, and your pull on the stick is constant. Naturally, none of these things will happen as you slow down, but once you arrive at the test point airspeed, they must be stabilized. Technically, you should not retrim if your horizontal tail uses a movable trim device like a tab or movable stabilizer. If the trim mechanism is an internal spring/friction system, retrimming is okay.

When you're sure you're stabilized, record your observed airspeed and OAT and time your altitude change. Don't rely on the vertical speed indicator value to determine your descent or climb rate. The VSI is too coarse for this test. Timing the altitude change will give you more accurate, refined data.

Your airplane's performance will dictate how long your timing should be. It should be long enough for you to have confidence in your data and short enough for you to maintain the rock-steady test point flight condition. Generally, time for 30 seconds or an altitude change of 500 feet, whichever occurs first. (You can record the VSI reading to corroborate your timing.)

After you've recorded the data, relax your pull on the stick and take a break. Then apply a push to the stick and establish your next target speed, which in our example would be 80 knots. You'll most likely be descending now, which is good because it will bring you back toward your initial level flight altitude. Perform the same test at this new, faster airspeed. Take another break, and then perform the 65-knot test point, and so on until you have data spread at approximately 5-knot increments from 65 to 100 knots.

That's all there is to it.

By the Numbers

1. Establish a level flight condition with the airplane trimmed for hands-free flight; set the altimeter to 29.92.
2. Record the altitude, observed airspeed, and OAT.
3. Using only the control stick/yoke, establish a new airspeed a few knots slower than the speed recorded in Step 2.
4. When absolutely steady, begin timing, noting the altitude when timing begins.
5. Record the new airspeed and OAT.
6. Time for 30 seconds or 500 feet of altitude change.
7. Record the altitude passing when timing is complete. Record the elapsed time.
8. Using only the control stick/yoke, establish a new airspeed a few knots faster than the speed recorded in Step 2.

OAS (knots)	PA1 (feet)	PA2 (feet)	Alt Chg (feet)	Time (sec)	ROC (ft.min)	OAT (deg C)	Avg PA (feet)	Avg DA (feet)	TAS (knots)	FPA (deg)	Remarks
75	2500	2500		NA		8					
70	2500	2490		30		8					
81	2400	2375		30		8					
66	2300	2250		30		8					
85	2200	2150		30		8					
61	2100	2025		30		8					
92	1900	1775		30		9					
99	1600	1350		30		9					

Flight Test Data	**Post-Flight Calculated Values**
OAS = Observed airspeed	Alt Chg = Timed altitude change
PA1 = Start timing pressure altitude	ROC = Calculated rate of climb
PA2 = End timing pressure altitude	Avg PA = Average pressure altitude
Time = Time for altitude change	Avg DA = Average density altitude
OAT = Outside air temperature	TAS = True airspeed
Remarks = well, remarks	FPA = Vertcal flight path angle

Figure 2

9. Repeat Steps 4 through 7.
10. Continue this alternating slower/faster process until all planned airspeed test points are accomplished.
11. Reset your altimeter to the local setting.

The Fine Print

How am I supposed to maintain an off-trim airspeed within one knot for 30 seconds! Calm air is essential. The slightest turbulence can upset your airplane enough to cause bad data. Even if the airspeed indication doesn't change, the fact that your plane was just shoved up or down can ruin the test point. If you catch a rogue gust, just restart the test after you re-establish the steady flight condition.

Wiggling control surfaces also contaminate data. It's possible to maintain a constant airspeed while rapidly moving the stick fore and aft, but the resultant tail wagging creates drag that can affect your results.

Don't chase the airspeed needle with your airplane's nose, because the airplane will never really stabilize at the desired speed. Similarly, using an artificial horizon to maintain your pitch attitude will likely lead to frustration. An analog attitude indicator is too coarse, and you might end up chasing that last pixel on an electronic display on your quest for steady, constant-airspeed flight. Use the real horizon to hold the required pitch attitude. The relative position of the airplane's nose and the horizon will show tiny pitch changes before any instrument will indicate a change.

There are a couple of gotchas, however. If you move your head, you'll change the visual relationship between your plane's nose and the horizon. One way to avoid this is to put your head against the headrest and move just your eyes to look in different directions. If you don't have a headrest, you can put a grease pencil mark on the windscreen so it lines up with the top of the cowling. As long as the mark and the cowling top line up, your eyes will remain in the same spot.

This test presents some challenging flying. Any pilot can do it, but not indefinitely. As soon as you're sure the airplane has stabilized on the test point flight condition, begin timing. While you're waiting for that 30 seconds to pass, note the airspeed, OAT, and anything else—such as VSI—you want to record. Note the OAT in the middle of the altitude change.

So how do you write down all this stuff while concentrating on flying with your head glued to the headrest? Don't. Make a mental note of airspeed, OAT, start altitude, and end altitude during each test, and then write them down when you finish testing that speed. Or you can use a small video or audio recorder or a co-pilot to record the numbers as you call them out. (No co-pilot unless you've completed the FAA-mandated fly-off time! And make sure any audio/video setup does not interfere with the flight controls or airplane systems.)

Flying with a co-pilot can be a good idea because he might detect an airspeed variation or excessive stick activity you might not notice when concentrating on flying the test point. Your scribe can also keep a rough plot of airspeed versus descent rate as a quality check on the data. Any data point that appears to fall far from the emerging curve is suspect. With this near-real-time analysis, you could re-fly the suspect points immediately rather than discovering them after your test flight.

Your attention will be focused on the horizon while your co-pilot performs see-and-avoid duties. If you don't have a co-pilot, you may want to perform clearing turns prior to each test.

Perform the tests in an order that keeps you near your original level flight altitude. Follow a climbing test point with a descending test point. You may have to perform two descending or climbing test points in a row to remain near the desired altitude. That's okay. You could return to your original altitude between tests, but this takes time and may force you to adjust power. Remaining within plus or minus 1,000 feet of your starting altitude should keep your data consistent.

It's okay to abort a test and re-fly it for any reason. After flying a few test points, you'll know when you nailed it and when you didn't. Making some kind of quality remark for every test point on your data card can help explain a data point that doesn't fall on the curve. If the not-so-high-quality points don't fall on the curve, you'll already have a good idea why.

Avoid changing the power settings between tests, if possible. It's nearly impossible to re-establish the exact power setting after you've changed it. While the particular power setting is not significant, the fact that it remains constant for all the tests is.

Finally, remember the flight test safety mantra—aviate, navigate, communicate, evaluate. Fly your plane first. Airspace boundaries, collision avoidance, engine temperatures, and many other considerations have higher priority than getting these data.

Next month we'll massage the flight test data in Figure 2 a little and construct the flight path stability curve. EAA

Ed Kolano, EAA 336809, is a former Marine who's been flying since 1975 and testing airplanes since 1985. He considers himself extremely fortunate to have performed flight tests in a variety of airplanes ranging from ultralights to 787s.

Hal's not-quite-perfect Gryphon in flight.

Big Lessons Writ Small

By Hal Bryan

I used to be afraid of building an airplane.

That's not exactly true; I was actually afraid of starting an airplane project and never finishing it, so I suppose I was technically afraid of *not* building an airplane. A recent experience building a very different sort of flying machine taught, or at least reminded, me that there's something even bigger of which I should be afraid.

A few months ago, my wife surprised me with a visit to a local museum that was hosting a traveling exhibit exploring some of the mechanical inventions of Leonardo da Vinci. Like many people, I've had a lifelong fascination with da Vinci's work. Among his surviving drawings are seemingly preternatural sketches of surprisingly plausible gliders and parachutes, a more fanciful would-be helicopter, and most famously, a mechanical human-powered ornithopter. Seeing some of these designs actually built, and in the case of a number of his earthbound inventions, actually functioning, was inspiring. So I did what I always do when I'm inspired at a museum: I stopped to buy something at the gift shop on the way out.

After a few minutes, I spotted a small flying model inspired by da Vinci's ornithopter, a rubber-powered, stick-and-tissue kit called a Gryphon that was targeted at builders age 14 and up. Even though I've been "and up" for more than 30 years now, I had my doubts about whether I could build it. My inspiration (read: my need to spend money) outweighed my hesitation, so I bought it anyway.

Several weeks later, I decided to build it in hopes that I could fly it at our annual "Family Flight Fest," a model aviation event we hold in the EAA AirVenture Museum. Blithely ignoring just about everything I've learned about building aircraft recently, I laid the parts out on a cluttered and poorly lit workbench in our basement, grabbed a bottle of what I'd call "probably the wrong

Photography by Hal Bryan

Senior communications advisor Dick Knapinski and Project Lead Chad Jensen work on riveting the top fuselage skin.

EAA Technical Aviation Specialist Tim Hoversten and Maintenance Tech Jerry Paveglio work on the center section.

EAA staffers work on setting the center section in place with the help of Zenith expert Tracy Buttles.

kind of glue" and a really dull knife and set to work. In spite of my efforts at self-sabotage, the build actually progressed, after a fashion. I nearly gave up when, thanks to the aforementioned dull knife, I tore a piece of the tissue used to cover the horizontal stabilizer. Instead of trashing it then and there, though, I took a breath and managed to trim it and shape it until it looked like maybe it was supposed to be curved like that.

I had to double-back a couple of times when I misread the instructions, and the areas where I trimmed the tissue with the bad knife and used a bit too much of the wrong glue looked pretty rough, but mostly it came together. Until it came time to attach two tiny brass cylinders that were integral to the flapping mechanism, and I realized that the parts in the kit were the wrong size—one was too big, the other too small. I didn't realize this immediately, as my default assumption was that it must have been me who was mistaken, not the plans or the parts. Once I'd accepted it, though, and realized that I couldn't adapt the existing components and there was no way I was going to finish it in time, I'm not proud to say that I just got frustrated and gave up.

Even though this was just a simple model aircraft, even unfinished it reinforced a few lessons I'd learned on our full-scale build. First, not every mistake is an automatic disaster: the curve that I added to the tail feathers to hide the fact that I'd torn the tissue paper by hacking at it with my near-useless blade actually looks pretty good. Would I simply reshape a part on our Zenith CH 750 build if I'd banged it up? Of course not—let me say that again, of course I wouldn't—but I wouldn't just quit the project and walk away, either.

Second, and more important, I was ridiculously impatient, rushing to meet a fairly arbitrary deadline. This impatience not only led me to use the wrong tools in an inadequate workspace, it affected the quality of my work, damaging the project even further.

As I said, I used to think that the biggest problem I'd face when building an airplane was the risk that I'd never finish it. When I looked at the aggressively mediocre job I'd done to that point on my ornithopter, it occurred to me that finishing a project *too soon* is potentially an even bigger problem than not finishing it at all. The rush to finish left me with something I wasn't proud of, and to a degree, didn't enjoy building. In the case of the model, the worst thing that would happen would be that it wouldn't fly and that maybe I'd be mocked by neighborhood teenagers. On a full-scale airplane, of course, the risks are far, far more serious. *(Continued on page 48)*

As simple as it sounds, then, that's what I should have been afraid of all along: impatience. Impatience led me to use the wrong tools. Impatience made me do sloppy work. And in this case, impatience also caused me to quit just because of a couple of missing parts.

The following Saturday, I was back to work on our staff build, beginning to assemble the firewall on our Zenith CH 750. I couldn't help but notice the contrast: On the Zenith build, we're spoiled to be able to work with no deadlines in a giant hangar with a ridiculous amount of space, plenty of light and heat, and an inexhaustible supply of expertise and support from colleagues and other experienced builders. In addition, we have access to every tool we could possibly need. Building the CH 750 is consistently enjoyable, and I'm extremely proud of the progress that all of us, myself included, have made so far. Impatience, thankfully, has never even entered into it, and if it does, I just have to remember the lessons I learned from da Vinci, by way of a toy bird.

By the way, I said that the ornithopter build had reinforced "a few" lessons, but I've only listed two so far. There was a third lesson, one that I'd written about in an earlier column, and that was that I remembered my resources. About a week after I'd given up, I sent an e-mail to the company that built the kit, and within a few hours, got the following response:

"I will send you some replacement parts. Thank you for calling it to my attention".

With that single e-mail, the "crisis" that caused me to quit and stomp away from my project like someone who was most definitely not "and up" just evaporated. The replacement parts showed up two days later, and I was able to fit them and finish my little Renaissance flying machine with no further drama. If this, like the others, seems like a ridiculously simple lesson, a common-sense reminder to ask for help when you need it, that's because it is. But sometimes it's the simplest lessons that need the strongest reinforcement.

As for the ornithopter, I'm still not proud of how it looks, at least up close, but it flies beautifully. EAA

The fuselage nearing the point of "Hey, this kinda looks like an airplane" stage.

Photography by Jennifer Bowen