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Vol.66 No.5 | May 2017

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Oshkosh! The Week You Love

No pencil required. Write your plans in ink.

BY JACK J. PELTON

I COULD MENTION the many top-notch air show performers who will be at EAA AirVenture Oshkosh this year. And list the several types of airplanes that will celebrate milestone anniversaries. And enthuse about the two night air shows that dazzle us all with pyrotechnics in flight, and the enormous fireworks display that closes the show. But I won't.

Instead I want to remind you of what isn't new at Oshkosh this summer.

First, thousands of airplanes will converge on Wittman field for the week. Hundreds more will splash down in nearby Lake Winnebago. For the week of July 24-30, Oshkosh will be the busiest airport in the world in terms of aircraft movements.

Second, hundreds of thousands of people of all ages and from every corner of the nation and globe will come together in Oshkosh. Their common bond is a shared love of all people and craft that fly.

Third, everyone who comes to Oshkosh will meet old friends and make new ones. As our founder Paul Poberezny always said, people come to see airplanes the first time, but keep coming back because of the people.

As the world of personal flying is pressured on all fronts, Oshkosh continues to expand. There was the inevitable dip in attendance immediately following the Great Recession of 2007 to 2009, but since then there has been steady growth.

There is a constant stream of new airplanes, particularly new amateur-built airplanes. And the aviation industry calibrates its design and production schedule so that the most revolutionary and important new airplanes, avionics, and accessories of all sorts make their public debut at Oshkosh.

Every summer I'm impressed by how the fleet of historic airplanes is expanding even though the actual age of the airplanes is increasing with each passing year. Incredible amounts of labor and money are poured first into restoring these airplanes and then flying that irreplaceable piece of history to Oshkosh for all of us to admire and learn from. History really does come alive — and take flight — at Oshkosh.

Another Oshkosh phenomenon that constantly impresses all of us here at EAA headquarters is the exponential growth in the number of people who camp on the grounds. We expand and upgrade our camping facilities every year, but demand is still running ahead so be sure to make your plans early.

What the camping numbers tell me is that more and more people want the total Oshkosh experience. When you camp on the grounds you are immersed in Oshkosh. The airplanes, the parties, and the endless list of evening activities are always just steps away. Your time in traffic will actually be a stroll across the grounds with the many other people who share your passion for aviation.

In the following pages of this issue of *Sport Aviation,* and in the next several issues to follow, you can read more about the highlights of this year's AirVenture. It is an exciting lineup, for sure. But you already know in your heart that you want to be here this July. Oshkosh is the place where everything looks right, makes sense, and gives comfort to all of us who love aviation.

I can't wait for July. *EAA*

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ON THE COVER Ted Teach's gleaming 1936 Ryan Sport Trainer, one of just five ever built. Photo by Jim Koepnick

ON THIS PAGE Phil Lockwood flies the latest AirCam factory demonstrator low and slow over Florida marshland. Photo by Erin Brueggen

For more on many of the topics in this issue, visit *www.EAA.org/sportaviation*.
To view and submit aviation events, visit *www.EAA.org/calendar*.

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ALL-IMPORTANT FEEDBACK

I READ THE ARTICLE by Steven Ells ("The All-Important First Start," Workbench, March 2017) about making devices out of plastic pipe for pre-oiling engines prior to start. He indicated they are to be used up around 50 psi. This is a very dangerous idea as PVC and other plastics are not rated or safe for compressed air service. I have been involved in accident investigations where plastic pipe has come apart explosively and sent shrapnel for a long distance. His quoted pressure rating for PVC is for liquid service only, which does not expand explosively upon pipe failure.

Take care and be safe.

–
Burl Skaggs, EAA 480138
Cameron Park, California

Three readers wrote telling me that due to the possibility of strength loss due to aging, reductions in strength due to stress risers from cutting threads, and the weakness of glued joints that PVC pipe — even pipe rated for 220 psi — should never be used in pressurized air applications. When PVC pipe fails under air pressure it explodes like a bomb, radiating outward in jagged shards.

Again, thanks for your help and expertise.
- Steve Ells

"The All-Important First Start" shows the engine running without its cowling on! This is the quickest way to ruin an otherwise good engine. The engine should never be run without the cowling in place according to the manufacturers of Continental and Lycoming. Hot spots develop very quickly and can spell doom for the engine.

–
Ted Hall, EAA 852248
Upperco, Maryland

He is absolutely correct — some sort of engine cooling must be installed if there's any power at all developed during a ground run. In addition to re-installing the cowling, it's permissible to conduct ground runs using a ground cooling plenum. When the photo was taken the engine was being run at low power (1200 rpm) following the after-installation visual inspection for a leak and magneto grounding check. Run time should be no more than two minutes. If there are no leaks, install the cowling and commence with the break-in flight. - Steve Ells

I would like to make a small comment regarding "The All-Important First Start" in the March issue of *Sport Aviation*.

While pre-charging the oil system on a fresh engine is preferred, it is not always available to everyone. Just as important, during an oil and filter change, until the oil filter is filled, no pressurized oil is being supplied to the bearings and other components. Being in the racing engine business, I recommend that the oil filter be filled with oil prior to installation. While that may not be practical on horizontal mounting, the filter element should at least be saturated prior to installation.

I also concur that ignition not be activated until positive oil pressure is observed.

–
Archie Frangoudis, EAA 258254
Merrimack, New Hampshire

Innovation and Interesting Jobs

Both of Beth Stanton's articles (Innovation's "Practical Solar" and "Cool Flying Jobs," March 2017) are certainly interesting, showing how flying can embrace new wrinkles in the fabric of flight.

Solar power certainly has potential along with battery electric and hybrid propulsion. In model aviation, electric power has supplanted gas/glow, and seeing similar happenings in some aspects of full-scale flying is where I think we'll be headed in a short time. Soaring/gliding and aerobatics come to mind as logical venues since the application is already there and will only improve with technological advances.

The different flying jobs article highlights that earning a living by flying does not necessarily mean a limited choice of options. Another example is Roger Dubbert at Zenith in Mexico, Missouri. He has flown more than 10,000 demo flights (along with his other flight work) with a perfect record in the 24 years he has been with them. EAA

–
Harold Bickford, EAA 567796
Auburn, Nebraska

SUBMISSIONS

LETTERS INTENDED for publication should be e-mailed to *editorial@eaa.org* or addressed to EAA/Letter to the Editor, P.O. Box 3086, Oshkosh, WI, 54903. Please include your EAA number, city, and state. All letters are subject to editing. Unpublished letters will not be returned.


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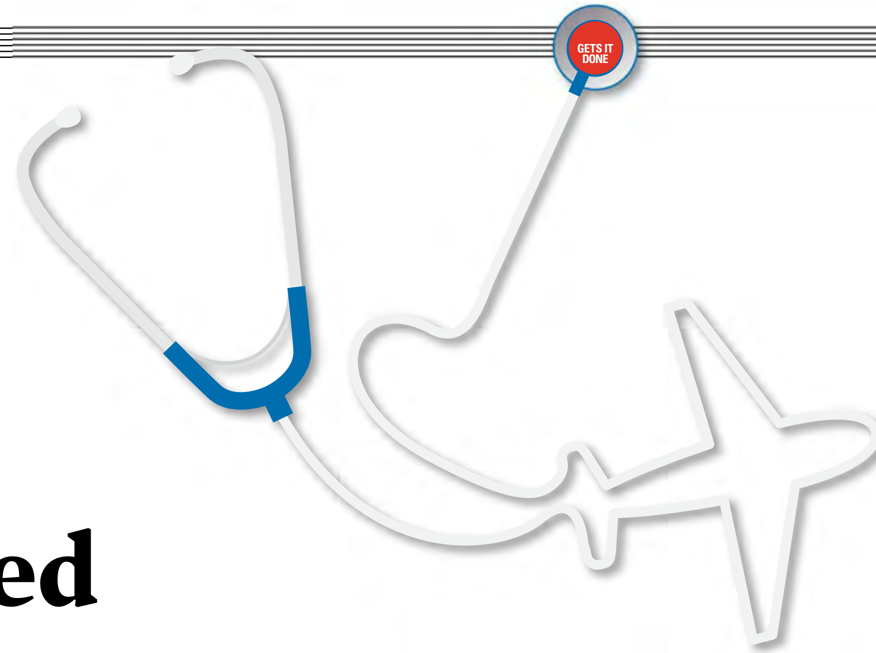


BasicMed

Ironing Out the Wrinkles

BY MACK DICKSON, EAA SENIOR GOVERNMENT ADVOCACY SPECIALIST

THIS MONTH, the FAA's BasicMed program becomes official and open to those who want to use it in lieu of a renewal of the third-class medical certificate. There are still questions, as there are with any new program of this nature, but one thing is certain: BasicMed is a viable pathway for thousands of pilots seeking relief from the burdensome requirements that exist in the third-class medical process.

It's important to look seriously at participating if you're in the group that is eligible for BasicMed. As the forms and online aeromedical course are introduced, and as pilots begin to fly under BasicMed, the program will begin to naturally take its place amongst the many medical certification pathways the FAA offers.

Since the FAA's announcement of the final BasicMed rule, EAA has fielded dozens of questions from members and pilots regarding the new program. Many of those questions center on aspects of BasicMed that will become more clear after its implementation. EAA will rely on our members in the field who are going through the BasicMed steps firsthand to report on their experiences.

Those who believe the long-established system of third-class medical renewals and special issuances better fits their needs than BasicMed can continue to use that system. For many pilots, however, the FAA's aerospace medical system has grown too burdensome for the simple, low-risk recreational flying they enjoy.

We receive phone calls on a daily basis from members applying to obtain special issuances for diagnoses that are increasingly common. Take early-discovered cardiovascular disease, for instance. Our members will tell us that the FAA is requiring them to undergo tests that their personal doctor insists are not necessary or, in addition, requiring testing that is excessively frequent. The testing is often costly and time consuming, and almost always reveals what the pilot and their doctor already know: they are healthy enough to fly recreationally. There's no doubt that the current third class medical process costs many pilots time, money, and stress on a regular basis.

There needs to be a better way. The current environment backlogs the system unnecessarily, delaying approvals of routine cases, postponing consideration of cases needing thorough review, and causing unnecessary time and expense for too many pilots.

BasicMed represents the largest single improvement in the FAA medical certification process in decades, after nearly a dozen attempts by EAA, AOPA, and others over the past 25 years. It is a step forward in a process frozen in time for too long.

There are many pilots who believe BasicMed does not go far enough, but the reform that was accomplished with this program was the most that was legislatively possible. Congress was not going to pass any measure that did not include a connection with a physician in some form.

Most of us see our family physician more often than what is required by BasicMed. To have a checkup with your personal physician at least once every four years is a prudent thing to do, whether or not one flies an aircraft. The ability to work with a local doctor who can see you in person and discuss your needs one-on-one, removing the FAA from the picture almost entirely, is a leap forward from hoping to get the okay from Oklahoma City.

BasicMed is progress, but progress that can only be measured if pilots use it. As BasicMed takes effect, EAA will continue to explore further steps forward regarding aeromedical certification.

SEN. JAMES INHOFE INTRODUCES FAIRNESS FOR PILOTS ACT

IN MARCH U.S. SEN. JAMES INHOFE (R-Oklahoma), a long-time EAA member and pilot, introduced the Fairness for Pilots Act (S. 755), which includes most provisions of the Pilot's Bill of Rights 2 not related to aeromedical reform. The medical reform provisions were included in a separate measure signed into law last July that led to the FAA's new BasicMed process.

Among the sections of the Fairness for Pilots Act are:

- Expansion of the original Pilot's Bill of Rights, including the ability for a pilot facing FAA investigation to appeal to a federal district court; requirements for the FAA to specify the activity that began enforcement action; and mandating the FAA to provide a copy of the releasable portion of the Enforcement Investigative Report.
- Limits re-examination of covered certificate holders.
- Expedites updates to the NOTAM program, including a fully maintained internet database that is searchable and includes temporary flight restrictions.
- Access to covered flight record data maintained by contract towers, flight service stations, and controller training programs.
- Increases flexibility to resolve enforcement cases when new information is brought forward.

The new legislation was scheduled to go before the Senate Commerce Committee beginning in April.

CLARIFYING REPAIRMAN CERTIFICATE ELIGIBILITY

WE RECENTLY SUMMARIZED the eligibility requirements for a repairman certificate under FAA Order 8900.1. This generated a few questions regarding whether or not a repairman applicant must have built the aircraft in question. To clarify, FAR 65.104(a) requires the following of a prospective repairman:

- Be at least 18 years of age.
- Be the primary builder of the aircraft (in the case of a group build, any member of the group may apply).
- Have the requisite skill to perform condition inspections.
- Be a United States citizen or permanent resident.

The guidance in Order 8900.1 directs inspectors on how to implement the above rule. It states that the FAA will accept evidence that the applicant has built the aircraft as satisfying the "requisite skill" requirement, essentially making the second and third requirements very similar. The FAA may also accept proof that the applicant has the ability to perform a condition inspection, but the requirement that the applicant is the primary builder still stands.

For more information on these stories and others, visit *www.EAA.org/Advocacy*.

ATC PRIVATIZATION WILL NOT HELP GA

BY SEAN ELLIOTT, EAA VICE PRESIDENT OF ADVOCACY AND SAFETY

THE OPPOSITION TO ATC privatization shared by EAA and many in the GA community may be counterintuitive to some, and understandably so. After all, less government is good, right? Smaller, smarter government oftentimes is good, and frankly, that is what EAA supports through many of its advocacy efforts. In the case of air traffic control, however, a privatized system poses a significant threat to GA. We need our government to own management and oversight.

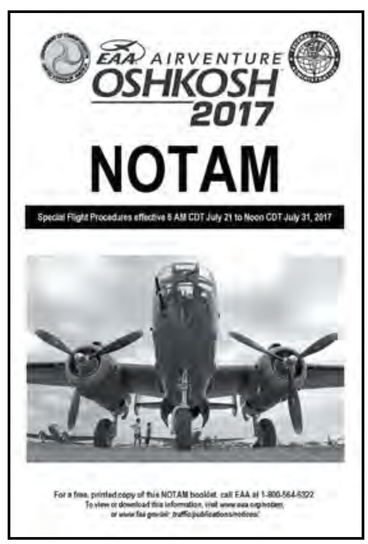
Is there a problem with our current ATC system that privatization would solve? My experiences in the national airspace system with ATC have been very good over the past 10 years. Can you remember the last time you were held up due to ATC bottlenecks? I can't. NextGen is often cited as the driving reason why a privatized ATC system needs to happen. NextGen is an ambitious modernization program and certainly has gone over budget and past deadline in many respects, but that is a separate issue versus handing over the air traffic line of business to a private entity.

The fundamental question remains: What is wrong with our current ATC system? The answer is clear — funding. Congress has not been able to provide steady funding due to continual CRs (continuing resolutions) that are a result of lack of agreement for an actual term of authorized spending. As for GA, our current system is our best system and a key element of the industry's and community's continued health. What amazes me is that the airlines can get behind something that would cause great harm to GA — the very source of their new hire pilots. Aviation is too fragile to harbor such disregard for the community the airlines depend on for staffing.

Privatized ATC in the United States is not the answer for the strongest general aviation community in the world! EAA

EAA AirVenture Oshkosh 2017 NOTAM Now Available

THE FAA HAS RELEASED the EAA AirVenture Oshkosh 2017 Notice to Airmen (NOTAM), featuring arrival and departure procedures for EAA's 65th annual fly-in convention July 24-30 at Wittman Regional Airport in Oshkosh, Wisconsin.



The NOTAM, which is in effect from 6 a.m. CDT on Friday, July 21, until 12 p.m. CDT on Monday, July 31, outlines procedures for the many types of aircraft that fly to Oshkosh for the event, as well as aircraft that land at nearby airports.

The NOTAM was designed by the FAA to assist pilots in their EAA AirVenture flight planning. While the overall procedure is similar to past years, there are some changes compared to the 2016 version, including:

- Temporary flight restrictions expected 10-11 a.m. CDT Friday, July 28, and during the afternoon air shows Monday-Sunday, July 24-30
- Military area changes in central Wisconsin
- Oshkosh Taxiway Bravo designators changed
- Aircraft camping allowed at Appleton International Airport (ATW)
- IFR arrival and departure routings
- Airports added to IFR Special Traffic Management Program

Pilots can download a digital version of the NOTAM or order a free printed copy online at *www.EAA.org/notam* or call EAA membership services at 800-564-6322.

To further assist pilots flying to Oshkosh this year, EAA's volunteer NOTAM Chairman Fred Stadler is hosting a June 14 webinar that will highlight special tips and other aspects of the NOTAM fly-in procedures. Register at the EAA website at *www.EAA.org/webinars*. In addition, the NTSB has published an informative safety bulletin about arriving to a major fly-in event, which can be found at *www.EAA.org/extras*.

B-29 *DOC* TO ATTEND AIRVENTURE

THE FULLY RESTORED B-29 Boeing Superfortress *Doc* will make its first appearance at EAA AirVenture Oshkosh this summer. The classic bomber made its first flight in July of 2016, more than 15 years after arriving in Wichita to be restored. "This will be a historic year for our airplane, and to say we're excited about our plans to tour in 2017 is an understatement," said Jim Murphy, manager for the Doc's Friends Restoration Program. AirVenture will be the last stop on *Doc*'s debut tour, which also includes visits at Yingling Aviation in Wichita, Kansas; Barksdale Air Force Base in Louisiana; and Whiteman Air Force Base in Missouri.

VOLUNTEER AWARD NOMINATIONS NOW OPEN

NOMINATIONS FOR THE DOROTHY Hilbert and Volunteer of the Year awards are now open. These awards serve as recognition for our volunteers who give so much to EAA year-round and make the World's Greatest Aviation Celebration possible every summer.

Both awards are given to volunteers who exhibit an extraordinary level of dedication to and passion for volunteering, but the Dorothy Hilbert Award is given specifically to a female volunteer in honor of the late Dorothy Hilbert, the award's namesake. The selected volunteers will be presented with their awards during EAA AirVenture Oshkosh 2017 on Sunday, July 23, at Volunteer Park.

Nominations can be made via the links at *www.EAA.org/extras* or by contacting EAA Volunteer Program Manager Cassie Bruss at *cbruss@eaa.org* or 920-426-4856. Some basic information such as name, EAA number, and details of the nominee's volunteer service will be needed, and the deadline for submissions is May 31.

PHOTOGRAPHY BY **ERIN BRUEGGEN**

EAA STC APPROVED FOR TRUTRAK AUTOPILOT

THE SUPPLEMENTAL TYPE CERTIFICATE process that EAA pioneered in 2016 set the stage for another success story, as EAA affiliate EAA STC, LLC has received an STC for installation kits for the TruTrak Vizion autopilot in a select group of aircraft.

The STC approval means that installation brackets and hardware for the TruTrak autopilot can be installed for the Vizion autopilot in Cessna 172 F through R models and all Cessna 177s. TruTrak received its parts manufacturing approval for the Vizion autopilot on March 30.

The EAA STC for the TruTrak installation kits will be available as the remainder of the Vizion autopilot approval nears its completion this summer. TruTrak sold the installation kits during this year's SUN 'n FUN International Fly-In & Expo, which includes all required mounting brackets, AN hardware, and a free wiring harness.

"Approval of the EAA STC and our facility PMA are two huge steps forward in this certification process," said Andrew Barker, TruTrak CEO. "It has been a pleasure working with EAA and the FAA on this project, and we are eager to keep this momentum pushing forward and finishing the rest of the approvals by summer."

CESSNA 190/195 70TH ANNIVERSARY CELEBRATED AT AIRVENTURE 2017

THE INTERNATIONAL CESSNA 195 Club is celebrating the 70th anniversary of the Cessna 190/195 type this year at EAA AirVenture Oshkosh. The 190/195 was based on the Airmaster design of the 1930s and was the beginning of business air travel. Activities planned include a flightline gathering the evening of July 25, a display and interview in the Vintage Interview Circle, type club parking along the Vintage flightline, and an open forum for owners and enthusiasts. If you are planning on attending the 70th anniversary celebration of the Cessna 190/195 by flying in, please register via the form at *www.EAA.org/extras*.

EAA LAUNCHES PROGRAM FOR VFR PILOTS

NON-INSTRUMENT-RATED PILOTS LOOKING TO improve their safety skills and knowledge will now have an additional resource through the new EAA VMC Club. Based on the IMC Club, VMC Club will be a volunteer mentor program designed to enhance pilot proficiency and create a community of aviators to share information and promote safety.

"VMC Club provides organized hangar flying focused on improving aeronautical decision-making," said Radek Wyrzykowski, EAA's manager of flight proficiency. "We focus on practical knowledge and the exchange of experience because we believe that safety and proficiency are better developed through hands-on knowledge."

VMC Club will be offered through EAA's chapter network, and there is no cost to chapters or members to participate in the program. Monthly club meetings will use real-world scenarios to engage participants and allow the exchange of information to improve awareness and skills.

More information on VMC Club, including a guide on starting a club in your area, is available via the link at *www.EAA.org/extras*.

REGISTER TODAY FOR WOMEN SOAR *YOU SOAR*

REGISTRATION FOR EAA'S 2017 Women Soar *You Soar* program, presented by Honda Aircraft Company, is now open. The four-day camp for high school girls, grades 9-12, is designed to engage, inspire, and educate young women about the world of aviation. Held annually at EAA AirVenture Oshkosh, the 2017 event will take place July 23-26 and includes hands-on workshops, mentoring sessions, and career exploration.

Attendees of Women Soar *You Soar* are offered a tram tour of the AirVenture grounds, team bonding sessions to break the ice, and a tour of the EAA Seaplane Base, weather permitting. Participation in the day camp also includes access to WomenVenture activities such as the power lunch and Women in Aviation breakfast. Once registered, Women Soar *You Soar* attendees are also eligible for a number of flight-training scholarships.

To register for Women Soar *You Soar*, apply for scholarships, or find out more about the program, visit *www.EAA.org/extras*.

NOTICE OF ANNUAL BUSINESS MEETING

IN ACCORDANCE with the seventh restated bylaws of the Experimental Aircraft Association Inc., notice is hereby given that the annual business meeting of the members will be held at the Theater in the Woods on Wednesday, July 26, at 8:30 a.m. at the 65th annual convention of the Experimental Aircraft Association Inc., Wittman Regional Airport, Oshkosh, Wisconsin.

Notice is further given that the election will be held as the first item on the agenda at the business meeting. Seven Class I directors (three-year terms) shall be elected. Candidates' names can be found at *www.EAA.org*.

–

JIM PHILLIPS, SECRETARY, EAA BOARD OF DIRECTORS

PHOTOGRAPHY BY **JASON TONEY, DAN LUFT**

CUBS TO GATHER AT AIRVENTURE FOR 80TH ANNIVERSARY

A GATHERING OF PIPER J-3 Cubs will be held at EAA AirVenture Oshkosh 2017, July 24-30, in celebration of the iconic aircraft type's 80th anniversary. The J-3 is one of the most successful designs in aviation history, immediately recognizable by its signature Cub Yellow paint scheme and striking black lightning bolt stripe. To many people, the term Piper Cub is synonymous with general aviation.

Originally built for primary training, the J-3 was intended to be a lightweight and affordable option for those who were itching to fly even in the midst of a poor economy. After its introduction in 1937, more than 20,000 Cubs were built, thousands of which are still flying today.

A field of yellow is expected on the AirVenture flightline after more than 80 Cubs arrive en masse from Hartford, Wisconsin, on Sunday, July 23. Cub owners planning to fly to Oshkosh can register to participate in the gathering and stay up to date on upcoming activities via the link at *www.EAA.org/extras*.

"We are once again excited to host a gathering of Cubs at Oshkosh," said Rick Larsen, EAA vice president of communities and member programs, who coordinates AirVenture features and attractions. "Cubs have introduced tens of thousands to the magic of flight and continue to provide joy to thousands of owners today."

MORE ASTRONAUTS CONFIRMED TO ATTEND AIRVENTURE APOLLO REUNION

Buzz Aldrin

Harrison "Jack" Schmitt

NASA ASTRONAUTS Buzz Aldrin (Apollo 11) and Harrison "Jack" Schmitt (Apollo 17), representing the crews who made the space program's first and last lunar landings, will attend EAA AirVenture Oshkosh 2017 as part of the Apollo program reunion on Friday, July 28.

Previously confirmed astronauts attending the event include Frank Borman (Apollo 8), Walt Cunningham (Apollo 7), Fred Haise (Apollo 13), Jim Lovell (Apollo 8 and Apollo 13), and Al Worden (Apollo 15).

The Apollo program's story is one of teamwork and tremendous achievement, each mission serving as a tribute to the accomplishments of those who had served on previous crews. The reunion is expected to be the largest gathering of Apollo astronauts at Oshkosh since the memorable 1994 Salute to Apollo program that brought together 15 of the men who were the faces of the American effort to put men on the moon.

"This will be a rare, unforgettable gathering of the people who met the challenge of flying to the moon and safely returning, representing hundreds of thousands of individuals who contributed to its success," said Rick Larsen, EAA's vice president of communities and member programs. "You may never get another opportunity to see these people in person and up close, as you will at Oshkosh this summer." EAA

Briefly **Noted**

EAA BOARD MEMBER and former NASA astronaut Charlie Precourt, EAA Lifetime 150237, was named chairman of a new safety committee for the Citation Jet Pilots Owner Pilot Association (CJP). Precourt, who also currently chairs the EAA Safety Committee, is a four-time NASA space shuttle astronaut, holds a commercial certificate and an instrument rating, is a CFI, and has more than 11,000 hours logged in 90 aircraft types.

UNMANNED AIRCRAFT SYSTEM ADS-B avionics manufacturer uAvionix Corporation has entered the manned aircraft market with the release of four new products designed to reduce the size and cost of avionics for general aviation aircraft owners. The EchoUAT is its remotely mounted ADS-B solution with EFIS compatibility and integrated Wi-Fi that supports EFB applications on iOS and Android, while the EchoESX is the company's ADS-B enabled Mode S transponder. SkyFYX combines a WAAS GNSS sensor with a RAIM processor to provide reliable navigation in challenging environments. GA pilots in the U.K. can take advantage of the SkyEcho, a portable, battery-powered ADS-B "out" solution.

EXTRA AIRCRAFT'S EXTRA 330LE AEROBATIC PLANE, powered by a Siemens electric propulsion system, set two speed records March 23 at Dinslaken/Schwarze Heide airfield in Germany. The aircraft, flown by company founder Walter Extra, reached 337.5 kph over a distance of 3 kilometers, which is 13.48 kph faster than the previous record for an electric aircraft weighing less than 1,000 kilograms, which was set by William M. Yates in 2013 in his electric Long-ESA. The Extra also set a new record in the electric aircraft over 1,000 kilograms category. A slightly modified configuration of the airplane was flown by test pilot Walter Kampsmann to a speed of 342.86 kph.

HARTZELL PROPELLER ANNOUNCED in April the approval of a supplemental type certificate (STC) for installation of its 83-inch composite Trailblazer propeller on Piper PA-12 and PA-18 aircraft. The STC is owned by Professional Pilots Inc., and the conversion program is being marketed through Hartzell. Doug Brewer, owner of Alaska West Air, was the first to install the Hartzell Trailblazer using this STC and reported better performance and improved efficiency.

For more information and direct links to Flightline stories, visit *www.EAA.org/extras*.

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BOEING

Manned Prandtl

The flying wing flies

BY BETH E. STANTON

ERICH CHASE, EAA 1049327, ran into his old friend Red at the Experimental Soaring Association Western Workshop in Tehachapi, California. Robert "Red" Jensen is operations engineer and chief pilot for subscale UAS aircraft at NASA Armstrong Flight Research Center. Red's boss, NASA Armstrong chief scientist Al Bowers, was giving a talk on the Preliminary Research Aerodynamic Design To Lower Drag (Prandtl-D) wing. The Prandtl-D wing design was inspired by early 20th century research by Reimar and Walter Horten and Ludwig Prandtl combined with observation of bird flight. Lift is distributed across a bell-shaped rather than traditional elliptical wing with twist, eliminating the need for a vertical tail and producing double-digit efficiency gains (see "The Prandtl-D Wing," Innovation, in the July 2016 issue of *Sport Aviation*).

Erich had been researching high-performance foot-launched gliders to build and was intrigued by the idea of using the Prandtl design. "I understood it not from the aerodynamic standpoint, but I got it that you twist the wing and get some forward thrust out of it," Erich said. "Because I'm a sailor, I know about twisting sails to get them to do different things."

Al and a team of graduate students and interns built quarter- and half-scale models of the wing over the last few years. Al's NASA report and technical paper, "On Wings of the Minimum Induced Drag: Spanload Implications for Aircraft and Birds," was published in March 2016. Since then, enthusiasts around the United States and abroad have been delving into equations and software, but a full-scale model had yet to be built. The quarter-scale models incorporated both the Horten brothers' and Prandtl's math. A subsequent half-scale model used a slightly different twist distribution that is pure Prandtl. When Erich decided that he wanted to build a full-scale model, this latest version had yet to fly. They didn't want to give him untested geometry for an airframe that would actually carry a person, so he built the proven earlier model.

Steve with spoilers deployed to check for pitch change.

The Prandtl wing lifts off on its third flight from El Mirage dry lake bed piloted by Steve Davey.

The Garage Band, L to R: Steve Slaughter, Albion Bowers (designer), Erich Chase (builder), Derek Abramson and daughter Annaliese, Steve Davey (builder and pilot), Red Jensen and son Ryan, Justin Hall.

BUILDING FULL SCALE

This is quite experimental, which I find enjoyable and challenging. — Erich Chase

Erich built the hollow, molded carbon fiber wing over the course of several months, using a three-axis CNC router, milling foam molds to build the skins. Proper non-linear twist couldn't be achieved with simple fixtures, so full female molds had to be fabricated. Halfway through the build, he halted and built a 12-foot model for early testing. The model did not fly well and exhibited tremendous adverse yaw with no roll authority. After much head-scratching and experimenting with different dihedral and anhedral angles to no avail, a CG issue was suspected. Red advised Erich to "start adding lead until it flew." Moving the CG forward was the magic solution. The wing flew perfectly, and he got back to work on the full-scale version. Four built-in tabs suspend a cage of aluminum tubes with a wheel in front and back and a sling seat to hold a pilot.

EL MIRAGE TEST

No one was more shocked by how well it flew than me. — Al Bowers

The team met November 6, 2016, at El Mirage dry lake bed in the Mojave Desert in California. Test pilot Steve Davey helped build the wing and is a longtime modeler and hang glider pilot. Everyone felt confident that the wing would fly, but they were concerned about the CG and control harmony. "This is all new and untested," Red said. "There are no plans to follow and nobody to copy."

With Erich driving the truck, the first tow accelerated to 20 mph, allowing Steve to get a feel for the controls. With the stick full aft, the plane did not rotate. When the second tow increased the speed to 25 mph, they discovered elevon flutter. After tightening the Spectra control cables and re-centering the stick, the flutter resolved. On the third tow, the wing lifted off the ground for about 3 feet and 20 seconds, "kind of like the Wright brothers," Red said with a grin.

Steve felt the heavy nose required too much back pressure and adjusted his seat position to refine control input. A series of low-altitude flights commenced, increasing altitude in 5-10 foot increments. "Steve was a little on edge for the first few flights, but then got very comfortable," Al said. A conservative flight envelope was maintained with a 35-40 mph tow speed, 1,000-foot towline, and easy S-turns with no heading changes. Steve flew nine flights total, the last two the entire 4-and-a-half-mile length of the lake bed. His highest altitude was 80 feet. He reported that it felt like he was "in orbit." See *www.EAA.org/extras* for a video of the flight testing.

They decided to end on a high note.

"While we thought we were safe, we didn't want to push our luck," Red said. "There were things we could do better like instrumentation, a real test pilot, and more car tow experience. We can always learn things from other people."

"When you see this thing fly, it's hard to get the image of the way birds fly out of your brain. I see seagulls and pelicans every time because it just has that same sort of long wing feel to it, so elegant and benign," Al said. "I'm used to seeing these larger unmanned gliders fly, but now someone is *in it*, flying it in the air," Al marveled. "There is this part of me that thinks I can't possibly be doing this, it can't possibly be real."

NEXT TEST

This is the spirit of homebuilding 100 percent — a group of guys wanting to try a new angle and bit of technology. — Red Jensen

Al joked that the guys call each other "the garage band." Although they are testing published NASA data, they have used all their own material and hardware up to this point. The next test, planned for spring or summer 2017 after the lake bed dries, is more ambitious. Renowned test pilot Mark "Forger" Stucky is slated to fly the wing up to 2,000 feet. Changes to the glider will include solid control rods instead of Spectra cables and improved harness arrangement for towing. Enhanced instrumentation for data collection will include alpha beta probe, pitot-static system, GPS, and control position transducers. Pressure ports on the wing with fiber optic shape sensors will measure wing load. That data — along with the NASA report, wind tunnel, and flight test data — will complete their experiments.

"Unlike in the business world where you have intellectual property that you want to protect, in research, you want to give it to everybody to provide you with more data to either corroborate or invalidate your theories. I understand that people are skeptical," Red said. "We hope to break down some of the skepticism. There is a potential for significant gains."

"We are 95 percent of the way where we think we ought to be with what we now know," Al said. "We will be able to take real data and prove to the world it really does have 'proverse' yaw and that you really don't need a vertical tail and there is a new way to design an airplane." *EAA*

Beth E. Stanton, EAA 1076326, is a competition aerobatic pilot and president of Northern California Chapter 38 of the International Aerobatic Club. She can be reached at *bethestanton@gmail.com*.

FLYBY WORTHY?

Calling all photographers: Do you have a photo that you think should be showcased in *Sport Aviation*? We want to see it! Send your best photo to *editorial@eaa.org* along with details on what is pictured, where the photo was taken, and who took it.

WHAT
Quicksilver MX over South Florida State College

WHERE
Avon Park, Florida

PHOTOGRAPHER
George Karamitis, EAA 144192

Lessons in Learning

Through the eyes of a tailwheel instructor

BY STEVE KROG

I'VE HAD THE DISTINCT PLEASURE of teaching people to fly, young and old, for more than four decades. It began as a job to build flying time. Like many young pilots, I had a dream: I wanted to become an airline pilot.

A year or two passed while I built flight time. However, when I accrued enough time to be considered for the airlines, they were furloughing pilots. The final time I applied I was told to sit tight at least three more years before any new hiring would be done, and don't call us, we'll call you.

I've taught hundreds of students of all ages and backgrounds. Each offers their own unique challenge, and it is the instructor's responsibility to figure out how each student best learns. For as much as I've taught students, they, too, have taught me.

Frustrated, I gave up flying for several years and then a friend, Dick Hill, reignited the flame. I've been instructing regularly ever since. It became a lifelong passion continuing to this day.

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Some of the things I've been taught, or have learned to accept, are humorous, others have been frightening, and still others fall into the category of "I can't believe he/she has just done that."

PHOTOGRAPHY BY JIM KOEPNICK

STUDENT WITH AN ATTITUDE

Years ago, as chief flight instructor I frequently inherited students with whom other instructors were having difficulties. One student with a particularly bad attitude comes to mind. It was time for the student to solo, but the instructor was hesitant because of the bad attitude. I agreed to give it a try, flew for several hours, and felt the student was in the right frame of mind to solo.

After taxiing to the ramp area to drop me off, I told the student to taxi back to Runway 12 and do three takeoffs and landings. The student nodded, added power, and proceeded to taxi directly into the 3-foot snowbank on the ramp perimeter. No damage was done other than a bruised ego.

The next day we tried it again, this time completing the solo flight without incident. As the student taxied back to the hangar, we observed the student had become a "true ace of the base." The student, assuming we were watching from the hangar, lost focus, started smiling and waving, and proceeded to taxi directly into the corner of the hangar. Solo a success — score one for the hangar, airplane nothing. The student climbed out of the aircraft, inspected the damage, and walked away never to return. Two ego bruising experiences in two days was far too much for the student to accept.

I've had my share of experiences, good and bad, over the past four decades, but the good far exceeds the bad.

TAKEOFF INTO THE FOG

Early one spring morning I experienced a situation that caused me a near panic condition. I had scheduled two students to each fly their long solo cross-country flight. Both completed their final planning and taxied in trail to Runway 30. I observed both as they completed their run-ups. As the first student taxied into position, I looked toward the west and observed an un-forecast rapid-moving low-level fog bank hiding the western half of the airport. Assuming the students would see it as well, I expected both to taxi back to the hangar and wait for the fog to clear. Surprise, the first airplane taxied into position, added full power, and began rolling down the runway. I began screaming "no," but to no avail. The airplane disappeared into the fog. I remember thinking this cannot be happening and began listening for the over-revving engine and subsequent crunch, but it never happened.

The second student taxied into position and I thought, "No, not you, too." But after sitting on the centerline for a few seconds, the student taxied off the runway and back to the hangar. I asked the student what was going through his mind. He replied, "I saw the first airplane disappear into the fog and decided I better not go."

My mind was still racing wondering what had happened to the first aircraft. I decided to call flight service (FSS) to find out if the student had activated his flight plan and learned that he had. I could finally breathe again, so I asked FSS to contact the aircraft and ask if he had any problems on takeoff, which they did. The student replied, "No problem."

By the time the student returned several hours later, I was ready to offer a lecture the likes of which have never been heard at this airport. I remember meeting the student as he taxied onto the ramp and began chewing him for the full hundred or so yards to the hangar. I continued chewing while he shut down and exited the airplane. Finally, after exhausting my full vocabulary, some of which consisted of single syllable four-letter words, I asked what happened. Calmly, he replied, "I was so focused on the map and the instruments when I taxied into position, I never looked up to see the rolling fog bank. I added full power and only then saw the fog. I was committed so I did what you taught me, keep the wings level and one wing thickness above the horizon line on the artificial horizon. A few seconds later I was on top and could see it was clear to the west so I kept going." I congratulated him on keeping a cool head and apologized for the lengthy butt chewing. He went on and earned his private pilot certificate several weeks later.

THE OVERDUE CROSS-COUNTRY STUDENT

The overdue solo cross-country student is also one that requires a handful of antacid tablets. I've experienced a few of these, and several flights come to mind. The first involved a student who was not only overdue but overdue by several hours. I made radio calls and tried his cellphone but never received a response. Long overdue and several hours beyond his fuel range, I expected the worst. Finally, the Cub could be heard approaching the airport. The student landed and taxied to the hangar all smiles. Before I could say anything, the student commented that it was a great flight. When I quizzed the student about the length of time and being several hours overdue, the student smiled and offered that at each airport visited, the hangars called to him, and he looked in each to see what kind of airplanes could be spotted. It was a true pleasure flight for him, but one that probably shortened my life by a year or two.

THE OVERDUE PHONE CALL

Another time I sent a student on a solo cross-country, and the planned return time came and left. As I paced around the ramp looking to the southwest hoping to spot the overdue Cub, the phone rang. The voice at the other end, who is also a good friend, asked if I was sitting down. Then he chuckled and said the airplane is okay. Now he had me going. When his laughing ceased, he explained that my student had landed uneventfully but shortly after a sky diver had a chute malfunction, landing hard and breaking a leg. Consequently, the airport was immediately closed. My friend entertained my student for another couple of hours until the airport was reopened.

These are experiences but a few of us get to enjoy. I wouldn't trade them for anything.

SOLO FLIGHT FOLLIES

One spring afternoon a young student who had two or three solo flights logged was ready for some light crosswind work. We launched off turf Runway 36 (200 feet wide) dealing with a 10-15 degree, 8-knot crosswind. After practicing approximately 10 very successful landings, I decided to exit the Cub and allow the student to try a few more solo landings. The first was good, followed by a second that was a bit shaky. The third was one of the most interesting I've ever observed. Forgetting to add aileron the Cub drifted to the right. Then too much aileron was added dropping the left wing, all while the airplane is still 3-4 feet in the air. Following a hard touchdown and a spectacular bounce, the poor Cub made several significant S-turns, then exited the runway to the left missing the gliders that were tied down, through the drainage ditch passing between two runway lights, and came to a stop on the centerline of Runway 29 pointing westward.

I finally caught my breath and assumed the student would taxi to the hangar. Instead, power was added and a takeoff was made from that point. Now I'm quite concerned. I've got a frightened student in the air unsure of what to do. The student climbed to pattern altitude and proceeded to fly around the airport for several laps. Rather than upset his thinking with a radio call, I opted to let him first clear his head. Several minutes later he entered the pattern for Runway 36 and proceeded to made another three to four excellent crosswind takeoffs and landings.

After taxiing back to the hangar, he shut everything down and just sat in the Cub with a big grin. When asked to explain, he replied, "I knew exactly what I'd done wrong and I knew I hadn't hit anything on the ground, so I just took off again, cleared my thinking, and came back in to land. This time I could hear your voice, though — left wing down, right rudder, flare, flare, flare, stick all the way back and in the corner." Just another life-shortening experience in a flight instructor's day!

I've had my share of experiences, good and bad, over the past four decades, but the good far exceeds the bad. Self-satisfaction is immeasurable when you see a student complete a first solo flight, demonstrate spins unassisted, pass the checkride, and take a passenger for a flight for the first time. These are experiences but a few of us get to enjoy. I wouldn't trade them for anything. EAA

Steve Krog, EAA 173799, has been flying for more than four decades and giving tailwheel instruction for nearly as long. In 2006 he launched Cub Air Flight, a flight-training school using tailwheel aircraft for all primary training.

PHOTOGRAPHY BY JIM KOEPNICK

J. MAC MCCLELLAN

COMMENTARY / LEFT SEAT

The FBO Problem

It's high costs for everyone involved

BY J. MAC MCCLELLAN

IF YOU WANT TO raise the blood pressure of pilots, bring up fuel costs. If you want to put that same group into orbit, mention ramp and handling fees. There is no hotter topic among pilots. That is, unless you talk to a pilot who just landed at an airport with nobody around where what passes for an FBO is locked up, and he and his passengers can't find a restroom, much less a rental car or a way through the fence. That pilot, at the moment, isn't thinking about fuel prices.

I wouldn't say the FBO business is in crisis, but it certainly is under stress. At busy airports you find gleaming facilities with every amenity pilots and passengers could wish for. At thousands of smaller fields there isn't enough business to support much more than self-service fuel and limited hours of staffing.

We're flying in a bifurcated world of busy FBOs that must recover the high costs of their operations through high fuel prices and ramp fees, and the other half that has so little business that the cost of staying open is higher than the meager income. And pilots are caught in the middle. Without a reliable network of FBOs our airplanes are nearly worthless as traveling machines.

Until the 1980s most FBOs relied on income streams from new airplane sales, maintenance, hangar rent, flight training, airplane rental, at least some charter, and fuel sales. For all sorts of reasons those FBO business segments evaporated leaving pretty much only fuel sales to fund the entire operation.

That's old news that we've all chewed on for years. But there are other more recent developments that have added to FBO operating costs that must be recovered from pilots who stop there.

One of the big impacts most of us seldom think about is the fallout of the 9/11 terrorist attacks. In the wake of that disaster every airplane and every airport became a suspect in the public's and politicians' eyes.

PHOTOGRAPHY BY **ERIN BRUEGGEN**

J. MAC MCCLELLAN

It didn't matter that the terrible damage was done by "heavy" airline jets; after the attack every airplane of any size was lumped into the threat category.

At airports with airline service, the reaction was immediate and uniform. Control of ramp access and identification of everyone on the airport side became a requirement. Fences were made more robust, gates more secure, and requirements for tracking all personnel on the "airside" more stringent.

Even at airports without scheduled airline service the rules for fencing and access and identification all increased if that facility wanted to receive government funding.

I was based at White Plains, New York, at the time, and we airplane owners all had to go through a TSA identification and screening process just to get to our airplanes. As I remember it, there were three different rounds of photos, fingerprints, and biometric data identification processes we submitted to as new and "improved" techniques were introduced.

While most of us general aviation airplane owners believe the security measures enforced after the attack were all an overreaction, that doesn't matter. The security forces — and more importantly the public — believe our airplanes can be a threat, and we're not going to win that argument.

Guess who got to pick up the costs of enforcing the new security procedures for GA? The FBO, that's who. The line crew and the rest of the staff had to go through identification procedures, control access to the ramp, and often escort, or at least observe, pilots and passengers as they come and go to their airplanes.

The result is higher costs for the FBO with no added income. And the security apparatus has created a huge inconvenience for pilots because the airport becomes essentially unusable when the FBO is closed. I was talking the other day to a crew who forgot to call the FBO to ask for "late staffing" for their after-hours landing to drop passengers. Taxiing to the ramp, no problem. But they couldn't get through the fence. They could see their cars parked on the other side, but with the FBO closed, they had no route through the fence, and it's tall and topped with barbed wire.

Finally an airport maintenance guy came by in a pickup and agreed to ferry the people around to their cars. But he couldn't use the gate at the FBO because it wasn't authorized, or locked shut, or something, so he had to drive to a far corner of the airport to a gate he was authorized to use. It took several trips to drive the passengers to their cars that were mere yards away on the other side of the fence.

We're flying in a bifurcated world of busy FBOs that must recover the high costs of their operations through high fuel prices and ramp fees, and the other half that has so little business that the cost of staying open is higher than the meager income. And pilots are caught in the middle. Without a reliable network of FBOs our airplanes are nearly worthless as traveling machines.

The FBO would have kept staff at the facility — for a hefty but probably still unprofitable fee — if the pilots had remembered to call. But my point is that the cone of security that has dropped over our airports costs us all, and the best an FBO can do is pass on the costs to break even.

The other development that has helped blow up the fuel sales income stream for many FBOs is the large and continuous improvement in jet engine efficiency. Years ago you couldn't fly a business jet very far without needing to take on fuel. But more recent designs are not only much more efficient, but they also have higher maximum landing weights, so pilots can carry fuel on multistop hops, which is convenient and often cost saving but deprives FBOs along the way of income.

Another cost-driving issue is rising expectations for what is an acceptable level of amenities at an FBO. Airport authorities who grant leases to FBO operators want, and often demand, a stylish, modern, roomy, and even plush facility. After all, the FBO is the first impression passengers will have of a city when they arrive, and nobody wants to yield any prestige to a city or state next door or across the country. And if there is more than one FBO on the field, they all have to compete to impress pilots and passengers with their service and accommodations. It's really easy to see where the high costs come from, and you get one guess who gets to pay.

While I'm listing cost burdens on many busy airport FBOs, it's also worth mentioning private fuel farms. Some airports, over the years, gave permission for locally based airplane owners to install their own fuel facility. That's great for the operator, but there goes one more source of income for the FBO leaving the visiting pilot — or one not big enough to have his own fuel farm — to pick up the tab for fuel sales income the FBO lost out on.

My memory is too foggy to recall exactly when the first ramp fees were introduced, but it was in response to the cost impacts I've listed, plus more. With costs piling up and pilots being able to "tanker" more fuel, FBOs decided a ramp fee was the only way to recover the costs. If you buy a minimum number of gallons based on your airplane size, the fee is waived. We've all worked the numbers, and if you buy the minimum fuel at the big FBO, the cost difference between that fuel bill and the lower cost small airport nearby is about equal to the ramp fee. No surprise there.

At first, only the biggest FBOs at the largest airports charged ramp fees. Now fees are the norm at even modest FBOs at not very busy airports. There are a few busy FBOs that have managed to continue without handling fees, but the number is dwindling. And with or without ramp fees the fuel prices at the big FBOs have to be higher than the smaller airport no matter what to cover costs.

It would seem that competition would bring down FBO fuel prices and ramp fees, but not always. The problem is traffic volume. The operating costs of an FBO are not going to be cut in half just because there is another FBO on the field. If there isn't sufficient traffic, the income from each FBO goes down while the costs remain the same. And if one FBO really excels in getting the big majority of the traffic, the other loses money and goes out of business, anyway.

Having said all of that, and understanding and even sympathizing with the challenges of the FBO business, I do believe some FBO fees and charges border on gouging. Having spent most of my career living and flying in the New York City area I like to think I'm immune to sticker shock. But when I encounter a $400-plus ramp fee for a King Air at a modest-sized airport in the middle of the country, I sure think that's chutzpah if not actual gouging.

The problem is I have no way of knowing what requirements and cost burdens the airport authority has put on that FBO. The FBO has a beautiful new building that it may have been required to build, and who knows what the airport is charging for the lease. But the FAA can find out. One of the requirements of FBOs and other businesses on airports receiving federal funds is that they charge fair prices that can be justified based on operating costs. And that's oversight I hope the FAA is taking seriously.

The other half of the FBO problem is at hundreds, even thousands of airports in smaller communities there simply isn't enough traffic to support more than minimum services. The cost of running a small FBO isn't high compared to the busy airports, but when the top line of income is tiny, any cost can be too much.

The great salvation for small FBOs and we GA airplane owners who use them has been self-service fuel. But in my experience the credit card readers on the self-serve pumps are finicky and not terribly reliable. Maybe it's because the card reader device is often exposed to the weather, or the dollar volumes being charged are much higher than at a car gas station, but I've frequently had problems getting the system to operate.

In my experience the small FBO has posted a name and phone number to call if you have problems. And friendly people have always been there to help me, give me a lift to a restaurant or motel, open the hangar door, and whatever else I asked. These are people like us who love airplanes and want to be around them and to help fellow pilots. Theirs is a labor of love, but it still has to pay the rent and put food on the table, and I worry that there isn't enough flying to assure that can go on forever.

But in my experience the small FBO has posted a name and phone number to call if you have problems. And friendly people have always been there to help me, give me a lift to a restaurant or motel, open the hangar door, and whatever else I asked. These are people like us who love airplanes and want to be around them and to help fellow pilots. Theirs is a labor of love, but it still has to pay the rent and put food on the table, and I worry that there isn't enough flying to assure that can go on forever.

Whether it is a glossy and swank FBO at a busy airport or a modest downhome operation in the country, we need them all. FBOs have been hit with repeated high-cost body blows over the past 20 and 30 years, and I admire those who remain. They have found various avenues to deliver the service we need and expect at the many kinds of airports that make this country's aviation system the best in the world. So the next time I launch into a tirade about FBOs I'm going to pause to remember where I would be without them. *EAA*

J. Mac McClellan, EAA 747337, has been a pilot for more than 40 years, holds an ATP certificate, and owns a Beechcraft Baron.

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You and Your Battery

Take care of it and it will take care of you

BY STEVE ELLS

THE MAIN BATTERY in your airplane is like that relative who is always there for you. If you need a few bucks to get through your latest financial miscue, or you need a place to stay for a couple of weeks, all you need do is ask. There's only one catch: You need to pay attention to that relative. For your relative, that means sending cards and calling; for your battery, that means maintaining it and keeping it charged for safe operation.

THE JUMP-START TAKEOFF AND WHY IT'S A BAD IDEA

Never take off immediately after using an external power source to jump-start an engine when the aircraft battery is too weak to start the aircraft. You'll get the engine started, but if your alternator or generator fails soon after liftoff, you'll find yourself without backup electrical power for more than a few minutes. Day VFR in a fixed-gear airplane? No big deal. Any other situation; you can be in a heap of trouble.

This is especially critical if engine ignition is dependent on battery power as was shown in 2007 when the crew of a Diamond DA42 had to put it down in a field near the airport immediately after they selected gear up after takeoff. The load surge created by the gear motor lowered the bus voltage momentarily, which caused the engine control units to shut down both Thielert diesel engines.

Your battery stores electrical power. A perfect battery would never lose strength or capacity, but all batteries weaken and self-discharge. They need attention. If a battery is maintained, it delivers the electrical energy to start the engine; it also acts like an electrical shock absorber by dampening electrical system surges, and it is your ace-in-the-hole for electrical power when the alternator or generator gives up.

The old, familiar flooded-cell lead acid battery — also called a dry-charged lead acid battery — is still around, but in most cases, owners should install an RG (recombinant gas) battery. RG batteries are also known as valve regulated lead acid (VRLA) or absorbed glass mat (AGM) batteries. It's easy to tell the difference — flooded-cell batteries have one removable filler cap per cell, and AGM batteries are sealed.

Gill RG 7035-28

RG batteries retain their charge more than three times better than flooded-cell batteries during periods of inactivity.

Flooded-cell batteries vent off acid during charging. This toxic corrosive cloud is controlled in older aircraft by a series of tubes that direct ram air through an enclosed battery box. Despite venting systems, it's common to see where the acid fog has stripped the paint off the lower fuselage aft of the battery box exhaust.

RG batteries are sealed; they don't vent anything. This, coupled with the elimination of the maintenance chores that are involved in the care and feeding of a flooded-cell battery, is why I installed an RG battery in my trusty Comanche.

I DON'T NEED NO STINKING BATTERY BOX

RG batteries are so well-sealed that they can be mounted in any position, although upside down

PHOTOGRAPHY COURTESY OF **GILL BATTERY** mounting is discouraged. There's no need for a battery box, but it's convenient to use an existing one. Box-free installations are common in kitbuilt aircraft.

RG batteries also retain their charge more than three times better than flooded-cell batteries during periods of inactivity.

Because the electrolyte (dilute sulfuric acid) in RG batteries is absorbed in glass mat separators, and because each cell has a pressure relief valve that's designed to maintain a positive pressure in each cell, the hydrogen and oxygen gases produced during the charge and discharge cycles are quickly reabsorbed (recombined). The glass mats provide support for the individual plates, so more plates can be packed into the same-size box, and plates are more resistant to shock and vibration damage than the plates in flooded-cell batteries.

RG batteries cost more. For example, the Gill RG 7035-28 is a direct replacement for its 12-volt, 35-amp-hour G-35 flooded-cell battery, and costs approximately 20 percent more.

THE INTERNAL-RESISTANCE EQUATION

Since the flooded-cell batteries have a higher internal resistance to electron flow than the RG batteries, they're best suited for airplanes with low-output generator-based charging systems. Skip Koss of Concorde Battery said any airplane with a generator that's rated at less than 50 amps (generator output is stamped on the data plate) should use flooded-cell batteries to prevent heat-related damage to the generator due to too high a charging rate.

Concorde RG24-10

The low internal resistance allows RG batteries to deliver more power and take less time to charge than a flooded-cell battery.

The low internal resistance allows RG batteries to deliver more power and take less time to charge than a flooded-cell battery.

However, this plus quickly turns to a minus if an RG-type battery is exposed to high voltages (15 volts for 12-volt battery and 30 volts for a 24-volt battery) since an excessively high charging voltage generates excessive internal case pressures that may crack the battery case or even blow it apart.

PHOTOGRAPHY COURTESY OF **CONCORDE BATTERY CORPORATION**

The C1 rate is equal to the rated capacity of the battery in amp-hours. This simply means that a 25-amp-hour battery is discharged at 25 amps and a 35-amp-hour battery at 35 amps.

CAPACITIES LESSEN WITH AGE

FAR 23.1353(h) requires that aircraft storage batteries "must be capable of providing at least 30 minutes (60 minutes for airplanes certified for operation above 25,000 feet) of electrical power to those loads that are essential to continued safe flight and landing." This is termed the "essential power requirement."

Bob Nuckolls, author of *The AeroElectric Connection: Information Service and Guide to Theory, Operation, Design, and Fabrication of Aircraft Electrical Systems*, said that a voltage reading across the terminals of a discharged battery will only be 10 percent or so less than the voltage reading of a fully charged battery, therefore static voltage readings are worthless in determining the health and capacity of a battery.

Capacity testing requires a fully charged battery be discharged at the C1 rate until the battery voltage drops to what's called the "end point voltage" (EPV), or "cut-off voltage," which is 10 volts (for 12-volt batteries) or 20 volts (for 24-volt batteries). The C1 rate is equal to the rated capacity of the battery in amp-hours. This simply means that a 25-amp-hour battery is discharged at 25 amps and a 35-amp-hour battery at 35 amps.

The Concorde Instructions for Continued Airworthiness (ICA) requires a capacity test once at 800 hours or around 11 months since new, whichever comes first, and then every 400 hours or around six months. During the test, the time it takes to go from fully charged to the EPV (at the C1 discharge rate) is noted. A fully charged 35-amp-hour battery should supply 35 amps for one hour. It's deemed to pass the essential power regulation if it can supply the 35 amps for 51 minutes (85 percent of 60 minutes) or more.

If the residual capacity falls below 85 percent of new battery capacity after the test, manufacturers require battery replacement.

Gill and Concorde manufacture and sell industrial-quality battery capacity testers that make battery maintenance tasks such as the residual capacity testing and battery charging easy on both flooded-cell and RG batteries. The Gill battery capacity tester/charger for 12- and 24-volt batteries retails for around $1,300. This is a little rich for many small maintenance facilities (and many owners), but there are options. Nuckolls published a parts list and schematic for a tester that compares the present capacity to the capacity of the battery when it was new.

Nuckolls also suggested a simple load test protocol that consists of using a voltmeter at the battery positive terminal when the battery is under load during an engine start. Grab the new battery reading when the fully charged battery is first installed and then compare that new battery voltage to the current battery voltage during the starting cycle at regular intervals.

Odyssey PowerSafe SBS-J16

MAINTENANCE

To extend the life of my RG battery I bought a small portable BatteryMINDer charger/maintainer/desulfator from VDC Electronics. It automatically charges the battery at a safe rate, adjusts the rate to compensate for ambient temperature changes, maintains a float rate to keep it charged, and has a pulse-type profile to address sulfation. I keep it connected to my battery through a simple plug I installed in the back wall of the airplane baggage compartment. I figure it's money well spent when I see the little green LED blinking because it means my battery is fully charged and being maintained at a float rate.

NEW BATTERIES

Gill and Concorde have been the go-to aircraft battery suppliers. Recently RG batteries by Odyssey PowerSafe have started to grab some market share.

Gill sells both flooded-cell and RG batteries. Concorde no longer sells flooded-cell batteries but has an RG battery for virtually every make and model of light airplane.

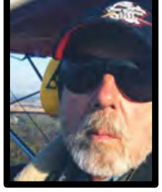
The Odyssey PowerSafe SBS-J16 battery is gaining popularity due to its smaller size and weight, ability to maintain a charge, short recharge times, and excellent cold cranking performance. This battery is FAA-PMA approved for installation in Piper PA-18 aircraft when installed in conjunction with an STC. STCs are for installation in some Piper PA-18 aircraft by Dan's Aircraft Repair in Anchorage and some Cessna 170s, most 172s, 180s, and 185s by F. Atlee Dodge Aircraft Services in Anchorage. Svenn's Aviation in Menomonie, Wisconsin, holds STCs to install the SBS-J16 in Piper PA-12, -14, -16, -18, -19, -20, and -22 airplanes.

The SBS-J16 weighs 15 pounds, about half the weight of other RG batteries, only measures 7 inches by 3 inches by 7 inches, is less expensive by around 25 percent, and is getting rave reviews due to those factors and a very slow discharge rate.

Take care of your battery, and it will take care of you. EAA

Steven Ells, EAA 883967, is an A&P mechanic, commercial pilot, and freelance writer. He flies a Piper Comanche and lives in Paso Robles, California.

PHOTOGRAPHY COURTESY OF **ODYSSEY BATTERY**



Ice Is Not Nice

It's always ready to strike the unwary

BY DAVE MATHENY

THE HUMIDITY ON THE DAY in question was hovering around 90 percent, while the temperature was about the same, resulting in a misery index of — just a guess — about 600. The only way to manage the heat, if you weren't going to a fly-in, was to draw up a chair next to an air conditioner and really lean into it. But if you just had to go to a fly-in (and you would just have to because you'd been looking forward to it since last year's brilliant event), then you would have to fly there in an open-cockpit aircraft, wearing a T-shirt, cutoffs, and sandals. Fortunately, my wife, Jean, and I had the T-shirts and all, plus a Quicksilver MX Sprint. We didn't want to miss this fly-in, which was held at a sort of classic picnic spot in a shady grove by a very large lake. When the soggy heat struck us after landing, we could always go wade in the lake.

I flew the first leg from an ultralight grass strip just east of the Twin Cities northwest to Gateway Industrial Airport, a small airport that, sadly, no longer exists. Jean brought the car; then we would trade off, and she would fly the 60-mile second leg. Navigation was as simple as it gets: Just fly straight north from Gateway — there's even a road to follow, Highway 47 — toward the southeast corner of Lake Mille Lacs, which is 14 miles across and would be visible from very far away, even in the humid haze.

ILLUSTRATION BY **DAVE MATHENY**

APPEARING AND DISAPPEARING

I could see her at first as I headed north on 47, catching an occasional glimpse through the trees, but then she disappeared. The MX cruises at about 45 mph, and I was doing 60, so I expected to get there ahead of her. Even so, when I arrived, I had a pang of concern when I couldn't see our brown, red, and gold MX among the various ultralights parked under the trees. My friend Larry approached with a very serious look on his face, giving me a deeper pang, but then said something like, "Did you know Jean had a forced landing?" I stifled an impulse to ask him how I could possibly have known that (this having happened in the era before cellphones), but I was grateful for the news that she was okay. He gave me a number to call, and I eventually found her.

She had been searching for a friend's house not far off her course and was reducing throttle steadily because, at her weight, even the little Rotax 377 would produce a climb at cruise-throttle settings. Eventually, she got tired of having to hold constant forward stick as the MX didn't have any pitch-trim setup. (Not a problem for me, weighing a lot more than she did; I later installed a bungee-trim system for fast cruise.)

She had felt the engine losing power and had advanced throttle to climb while searching for a suitable forced-landing patch. By the time the engine died, she had a good field picked out and landed in it uneventfully. After I collected her, we went to look the MX over, and the engine started on the first pull and ran nicely. It was now full night, so very early the next morning I flew it out of there and back to the home field. It was unfortunate that we had missed the fly-in, but I was glad she'd handled the forced landing so well.

INVESTIGATION

I suspected carburetor ice was the culprit. "Don't worry, ultralights don't get carb ice" I'd heard over the years, and had accepted as gospel truth. I had therefore never passed along any carb-icing concerns to Jean, who had gotten most of her aviation knowledge from me.

Let's review what causes carburetor icing. When atmospheric air accelerates as it passes through the venturi inside the carb, its temperature drops. Moisture in the air condenses into a fog and settles on the surfaces inside the carb, including the throat and the butterfly valve, where it can freeze. If the throttle is at a reduced setting — the exact amount varies — a steady ice buildup can occur, gradually choking off the flow of air; it can also immobilize the butterfly valve. There are YouTube videos that show the process. Although none look quite as malevolent and personal as what I've drawn, watching ice appear and grow inside the carburetor throat will strike a chill into any aviator's heart. It's worth noting here that people naturally associate "ice" with "cold weather," but that's a snare and a delusion. The first sentence in this essay was intended to raise a warning flag; 90 percent humidity — with temperature about the same — is a prime condition for carb ice to form.

To prevent this ice formation, normally aspirated aero engines are provided with an alternate-air source that draws intake air over the exhaust manifold to heat it up and raise the temperature above freezing. Standard practice in such engines is to use the carb-heat lever when reducing throttle below cruise settings.

Ultralight engines almost never have carb heat of any sort, either from electric heating or from passing the intake air over a heat source. But why are they supposedly immune to carb ice? Various explanations were offered, including the idea that the rubber socket that connects the carb to the intake manifold was somehow involved, or the simple fact that they are two-stroke engines somehow confers a magical protection all by itself. Why? Well, because they don't need it. Why is that? Because they don't ice up. Why don't they? Shut up, they explain. (Kidding! Nobody has ever said "shut up" when I persisted in asking about carb ice in two-strokes. It just conveys the dead-end nature of every inquiry I've ever made into the subject.) For what it's worth, on several occasions I've been curious enough to wrap a hand around the throttle body of a two-stroke carburetor on a summer day when the engine had been turning at low rpm for some time. It did not feel cold. Go figure.

IT'S A MYSTERY

I can think of two possible reasons for the seeming immunity of two-stroke engines to carb ice, although there are probably better ones out there. One, most ultralight engines are operated at nearly wide-open throttle in the first place, so any ice buildup will not narrow the passage very much. Two, the fuel-air passage in a two-stroke carb is configured differently from the typical aero-engine carb, and there is typically no butterfly valve, but instead a slide. So the two-stroke carb may not provide quite as friendly a surface for ice buildup.

It's also possible that carb ice is a more common cause of trouble in ultralights than people realize. Down the years I have witnessed many unexplained stoppages in two-strokes that caused forced landings but then cleared up miraculously afterward; one pull and the engine started and ran flawlessly. Were these caused by carb ice? Possibly. It's hard to say. A tablespoon of water from melted ice inside a carburetor next to a hot engine may not be noticed — especially if not looked for.

I strongly suspect that ice was the cause of Jean's forced landing. She was operating with the slide about half closed. The day was horribly humid, the air so laden with moisture that even a slight temperature drop would have resulted in actual fog.

People naturally associate "ice" with "cold weather," but that's a snare and a delusion.

UNWARINESS STRIKES AGAIN

I've had one other encounter with carburetor icing. On a long cross-country a lot of years ago in an Ercoupe 415CD, I kept reducing throttle very slightly, accepting a lower airspeed in exchange for reduced fuel consumption. It never occurred to me to use carb heat. By the time I got down to maybe 1900 rpm (from a typical cruise setting of 2300), the engine suddenly began to lose rpm. I immediately thought, "I'm an idiot," and pulled on carb heat and opened the throttle wide. The engine stumbled and grumbled a little, probably as it ingested ice, then came up to full power. Lesson learned.

So what's to be done? Simple: Use carb heat, if you have it, in any normally aspirated engine whenever reducing throttle very far below cruise settings. There are now carb-heat devices available for two-stroke engines in ultralight applications, although they seem to be mostly for the bigger engines such as the Rotax 912. If flying a two-stroke engine and you don't have carb heat, be wary of half-throttle settings. All pilots should always be wary on days with high humidity. Visible moisture, such as haze, means carb ice is almost certain. Intensely dry days, when the temperature is 10°F and you can see for 50 miles, are unlikely to produce carb icing, but I don't care. Haze or no haze, hot or cold, when I reduce power, I apply carb heat. Ice is not nice. EAA

Dave Matheny, EAA 184186, is a private pilot and an FAA ground instructor. He has been flying light aircraft, including ultralights, for 34 years. He can be reached at *DaveMatheny3000@yahoo.com*.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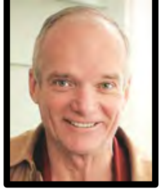


Respect, Not Fear

FAA collaborates with industry to get it right on new standards for slow flight

BY CHARLIE PRECOURT

IN AUGUST 2016 the FAA published a safety alert for operators (SAFO) on the subject of maneuvering during slow flight. They also drafted a revision to their *Airplane Flying Handbook*, Chapter 4, to state slow flight training would no longer allow for stall warning horn activation during the maneuver. The SAFO stated the purpose of slow flight is to gain an understanding of the aircraft's feel and characteristics near minimum controllable airspeeds and in the region of reverse command (the back side of the power curve). It asserts pilots need to learn these characteristics *but should not perform slow flight with the stall horn activated* as it creates the "negative training" of ignoring the horn. It follows that ignoring the horn is counter to the objective of avoiding stall and loss of control. Seems logical enough, right?

Well the dilemma came in the practical application of the draft new guidance. Rod Machado first published this concern in *AOPA Pilot* magazine back in December. He noted the FAA's initial draft of the Airman Certification Standards (ACS) would change the way pilots performed slow flight to be so far above the stall warning horn that you would not be in the region of reverse command. In fact, slow flight could have been flown per the draft standards above approach speeds. So how would we ever we really get to see the region of reverse command if we set the slow flight speed this high?

The initial SAFO also noted the old slow flight target speeds for slow flight of 3-5 knots above stall "would mean intentionally flying with the stall warning activated, which is a stall indication." This statement is debatable in my book, as a stall warning is not a stall indication. By definition, the warning horn is supposed to come on 5 knots before the stall. Stall *warnings* also include things like control sluggishness, airframe buffet, increasing stick forces, and increased adverse yaw with roll inputs. In short, the way the aircraft behaves in slow flight is a collective stall warning. The indications of a stall are aircraft uncommanded motions such as a *g*-break (nose drop) or significant wing drop; motions that signal an actual stall.

ILLUSTRATION BY **BRANDON JACOBS**

This is a very important outcome, and I applaud the process the FAA used to establish a working group and ensure they got this right. Had the original draft been retained we would have communicated that we want pilots to stay away from the stall boundaries, and that we ought to be fearful of the near stall region.

A final concern with the initial draft of the SAFO was pilot checkrides in slow flight would no longer allow for stall warning horn activation during the maneuver. Yes, this would have meant you would bust your checkride if the horn came on during slow flight.

So with plenty to debate in the drafted new slow flight standards, enter the Airman Certification System Working Group. This is a group of FAA, industry, and outside experts who reviewed the draft and have now amended it to address all of these concerns. The way out of the dilemma was to simply target slow flight in an airspeed range from onset of the horn up to 10 knots higher, and don't make it a bust if the horn occasionally comes on. Instead have the objective include appropriate response to get the horn back off by adding power and lowering the nose slightly, then resuming the slow flight maneuvering just above the horn. That reinforces doing what is appropriate if the horn ever comes on unexpectedly. What this would do is put slow flight back in the region of reverse command and get pilots to a proficiency level where they don't fear the horn (or other warnings) but they respect the warnings.

This is a very important outcome, and I applaud the process the FAA used to establish a working group and ensure they got this right. Had the original draft been retained we would have communicated that we want pilots to stay away from the stall boundaries, and that we ought to be fearful of the near stall region. In discussing this issue with Rod he noted that a lot of students have admitted they were afraid to stall and asked how they could get over their fear. Many also reported having instructors who expressed the same fear. My contention is, without fully exploring the slow flight and stall regime in your aircraft, you are *more likely* to have a loss of control issue. When was the last time you refreshed your knowledge of and feel for these characteristics in your aircraft? What we do when we perform approach to stall and stall in flight-testing is a good way to reacquaint yourself with how the airplane talks to you in this regime.

Make note of aircraft responses during the recovery such as wing rock, secondary stall, or any uncommanded motions. In flight test, these notes provide the narrative for the pilot's operating handbook.

In flight testing, we typically begin with clean configuration wings level and subsequently progress to gear and flap configurations and finally to maneuvering (departure, turning, and accelerated). For each of these, the general test technique is similar. We establish level flight at 15-20 knots above the predicted stall speed, at a safe altitude. When stable, make separate control inputs in each axis: roll, pitch, and yaw. The inputs should be just enough to generate about 3-5 degrees of aircraft response, then move the controls right back to neutral (usually a 1-2 second input pulse). Then watch for the aircraft response and oscillations. In roll, is there any accompanying adverse yaw? Does the aircraft stop rolling when the input is released to neutral? In pitch, does the aircraft return to the previous attitude? Is there any tendency for the pitch to continue to rise after releasing the stick? Does the pitch attitude continue to oscillate? The same questions apply in the yaw axis. Then slow 3-5 knots and repeat the process. Make note of any changes in response as the aircraft gets slower (it is normal to be more sluggish, but control response should still be positive). Make note of any stall warning cues. Watch closely for any uncommanded motions. At the first sign of any uncommanded motion (nose drop, wing drop, nose rise or slice), recover the aircraft by reducing angle of attack, adding power, and increasing speed.

If there are no surprises down to 3-5 knots above expected stall speed, then continue to a complete stall by bringing the elevator control slowly back until the stall indication occurs. There should be a continuous increase in stick force with aft deflection, which is both a stable characteristic, and a natural means of preventing inadvertent stall (in aircraft flight test, if stick forces get lighter we stop the test). Once you get to the stall, initiate recovery and record the altitude required to return to level flight. Also make note of aircraft responses during the recovery such as wing rock, secondary stall, or any uncommanded motions. In flight test, these notes provide the narrative for the pilot's operating handbook.

This thorough examination of the aircraft approach to stall and stall behavior not only allows us to properly verify that characteristics match expectations, but it also allows us to become intimately familiar with the feel of the aircraft in the slow speed regime. We end up with the aircraft less likely to surprise us, and a piloting skill that will keep us out of trouble.

Links to the SAFO, *Airplane Flying Handbook*, and Airman Certification Standards can be found at *www.EAA.org/extras*.

Fly safe! EAA

Charlie Precourt, EAA 150237, is a former NASA chief astronaut, space shuttle commander, and Air Force test pilot. He built a VariEze, owns a Piper JetPROP, and is a member of the EAA board of directors.

The McGee Community

Friends and neighbors sharing the spirit of aviation

BY LAURAN PAINE JR.

IT'S UNAVOIDABLE. When you meet with pilots to talk about a story you get a lot of peripheral stories, too. But, hey, I love it. That's what pilots do: talk. And laugh. And that's what we did when we met at Scott Chambers' house.

You see, I had received information from two different pilots about a fella named Fred Frederiks. Fred is a neighbor of Scott's so I invited myself to Scott's house to find out more. Scott is a former copilot of mine. Scott mentioned to Rick Doherty that I was coming, and Rick said, "If he's coming, I'm coming, too." (Rick is also a former copilot of mine.) And Tim James stopped by, a friend and talented serial builder from Aurora, Oregon. He's a story unto himself, but photographing him is like trying to take a picture of Bigfoot on a moonless night. He darts!

Fred in the Husky

Anyway, before we could get to the subject — Fred — we probably told 700 stories. What one doesn't remember, another does. Yammer, yammer, laughter, more yammer, and more laughter. That's the cycle, and it's grand! There's a whole lot of, "What ever happened to so-and-so?"

Scott went so far as to open his logbook and found some pages where I had given him, a new copilot, initial operating experience. He had dutifully logged the things we had done, but on the last day, he wrote "a really fun day." That was probably 25 years ago. And I remembered flying with Rick and him telling the story of when, right after he got his private certificate, he offered to take his dad, an eastern Oregon wheat farmer, for a ride. His dad responded, "Ain't got no use for it." That's okay; he was about raising wheat. You do what ya gotta do. And there were lots of pictures of beautiful grass strips in the Idaho backcountry that are made to order for the large-tire Cubs that Tim fancies. Talk about pictures of a bunch of happy smiling pilots; that's real flyin' right there!

Scott and Rick

PHOTOGRAPHY COURTESY OF **LAURAN PAINE JR.**

Now here my buddies are: Scott flying for United and Rick for Alaska. It did this ol' pilot's heart good to see them all growed up and doin' well. I laughed when they said, "Yeah, when we were flying with you, you were probably 50 years old, and we thought you were older'n dirt. Well, now we're 50-ish, and it don't seem so old." Nice that they had good memories of my working days — it made me feel good.

Now back to where I was going with all this: Fred. Several years ago, Scott got the itch to make the move to some farm property. He found McGee (67OR). It was a home on 40 acres located in Willamette Valley agricultural land, and it had a grass airstrip! Bingo! Jack McGee was the owner, but he had perished in a crash. His two sons — one a pilot — took the farm over and tried to keep it up but eventually put it up for sale. Scott made the deal. There was much work to be done, but Scott dove in, hammer and shovel in hand.

McGee on a wet winter day.

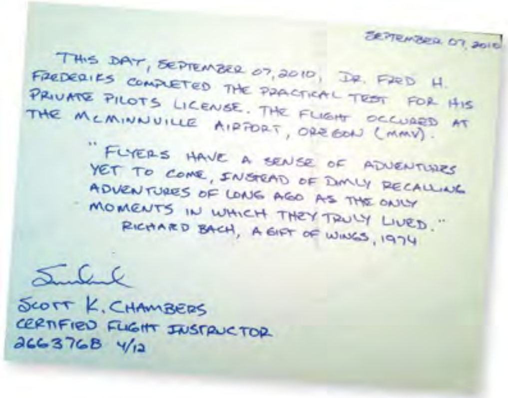
One day he was walking along the fence line and happened upon his new neighbor, Fred. Fred is a retired veterinarian, of Dutch ancestry, who remembers his folks talking of when the Nazis took the family farm. Scott introduced himself and mentioned that he was a pilot. Fred said, "You're not going to fly off the strip are you? We've had nothing but problems." How's that for an opening by your neighbor regarding your newly acquired dream airstrip? Scott took the high road, saying, "Let me know how to be a good neighbor." That was a good decision. Scott asked Fred, "Ever been flying?" Fred said, "No. McGee's never invited me." Scott continued with, "Would you like to go for a ride someday?" Fred wasn't immediately forthcoming with an answer, but a few days later he mentioned to Scott, "Maybe I would like to go for a ride someday."

Here is where Scott's aviation community of friends kicked in. Scott, at the time, had no airplane (except for the RV-8 he was feverishly working on) so asked his friend, John Fitzgerald (yet another former copilot of mine) if he'd give Fred a ride in his Cessna 185. John said, "Sure." After John took Fred for a flight, another friend, Jerry Trimble, took Fred for a helicopter ride. Fred liked the rides!

So then what happened? One day Fred mentioned to Scott, "Ya know, I might like to learn to fly." Since Scott is a friendly and caring type of guy, that was all he needed to hear to get the ball rolling. He sent Fred to Aurora Aviation at Aurora State Airport (UAO). There, his CFI was Sadie (who my oldest son once instructed with; her dad is a former F-16 pilot).

PHOTOGRAPHY COURTESY OF **LAURAN PAINE JR.**

LAURAN PAINE JR.



SEPTEMBER 07, 2010

THIS DAY, SEPTEMBER 07, 2010, DR. FRED H. FREDERICKS COMPLETED THE PRACTICAL TEST FOR HIS PRIVATE PILOTS LICENSE. THE FLIGHT OCCURED AT THE MCMINNVILLE AIRPORT, OREGON (MMV).

"FLYERS HAVE A SENSE OF ADVENTURES YET TO COME, INSTEAD OF DIMLY RECALLING ADVENTURES OF LONG AGO AS THE ONLY MOMENTS IN WHICH THEY TRULY LIVED." RICHARD BACH, A GIFT OF WINGS, 1974

SCOTT K. CHAMBERS
CERTIFIED FLIGHT INSTRUCTOR
2663768 4/12

Scott's note of Fred's success.

Fred flew with Sadie for 10 hours, then stopped by one day and said to Scott, "I think we ought to buy an airplane. What kind should we buy?" Scott's thinking — besides wow! — was something basic, like a Cessna 172 or a Cub (secretly mostly thinking Cub). So the community put their heads together and eventually found a Husky in Arizona. After a pre-buy inspection Scott and John went down to pick it up. Fred gave John a signed blank check. A blank check! For an airplane! Scott wrote the check, and then he and John flew the Husky to its new home at McGee and parked it in Scott's hangar.

Now Scott really had to spring into action because he had let his CFI expire. He set about to renew it with examiner Mary Crittendon (yup, another former copilot of mine). She put him through the paces and renewed his certificate. And then the real work began. Scott taught Fred ground school in his hangar and then began the flight instruction in the Husky. Scott said, "It was like teaching family. You don't want to leave any stone unturned. He was a friend and neighbor, and you're going to be watching him fly regularly. You wanted to get everything right." And he did. Fred soloed and later got his private certificate. He has more than 400 hours now and has flown the Idaho backcountry, the San Juan Islands, and many other interesting destinations.

So digest all that a bit: Scott meets his neighbor who wants nothing to do with airplanes flying off the strip adjacent to his property; Scott takes the high road of good neighboring, and Fred ends up buying an airplane and Scott teaches him how to fly with the help of a willing and supportive airport community of friends. It'd be great to see the story repeated in other locations across this wonderful land.

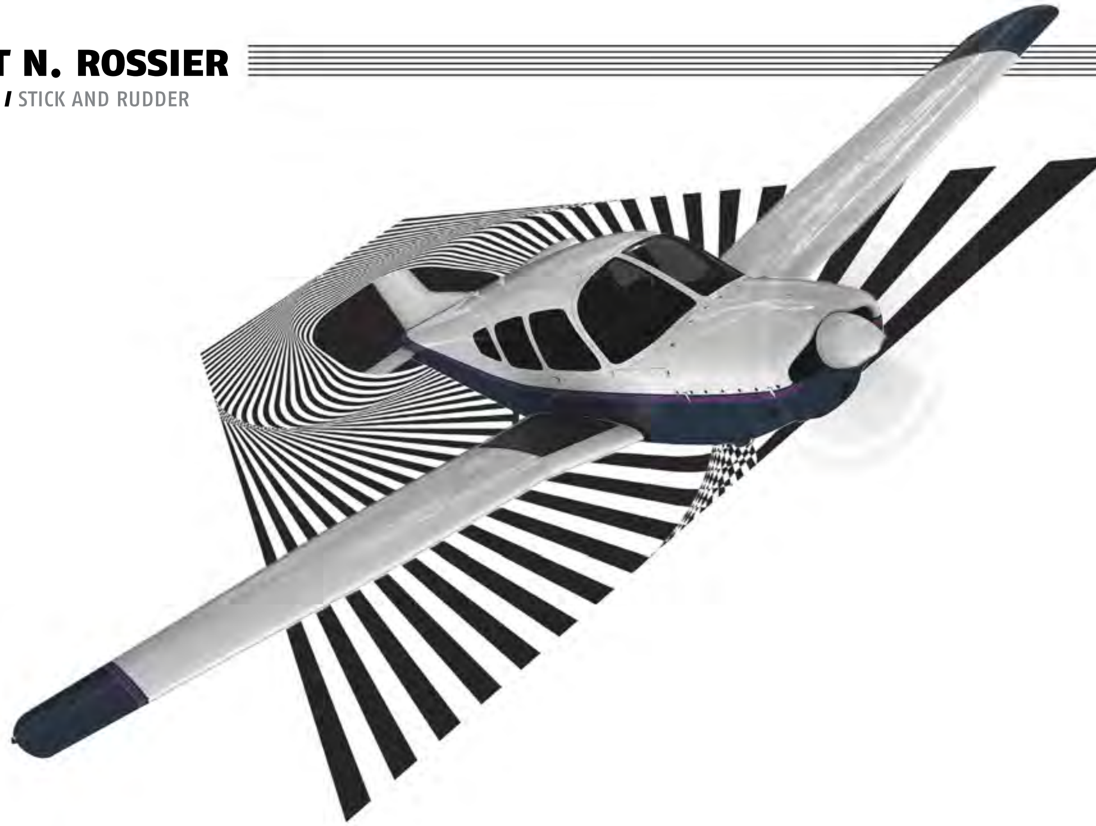
All this happened a few years ago. Fred is 75 now and winters in Mexico (where he volunteers at spay and neuter clinics, to give you a glimpse into the character of the man). Scott has since purchased the Husky, but Fred still flies it when he comes home; Scott is happy to honor that agreement.

During the day of storytelling, I learned something I did not know: Scott's dad, Dwight, was a Marine helicopter pilot in Vietnam. I always knew Scott was a patriot; now I know why. His father's Marine memorabilia is proudly displayed in the family room. In his spare time, Scott grows filbert trees, and he and his bride, Judy, also raise Labradors.

To me, it's a heartwarming story of airport community and Fred, a guy willing to try something new. The visit was, to paraphrase a friend of mine, "a really fun day." *EAA*

Lauran Paine Jr., EAA 582274, is a retired military pilot and retired airline pilot. He built and flies an RV-8 and has owned a Stearman and a Champ. Learn more about Lauran at his website, *www.ThunderBumper.com*.

PHOTOGRAPHY COURTESY OF **LAURAN PAINE JR.**



Illusions

Fooling ourselves in flight

BY ROBERT N. ROSSIER

YEARS AGO when I was working toward my instrument rating, my instructor set me up for an important lesson. Flying among the towering columns in the billowy wonderland just above a cloud deck, he told me to take my eyes off the instruments and just fly visually. Letting my eyes adjust to the outside scene, I soon was flying in what looked and felt like straight and level flight. When he then instructed me to get back on the instruments, I had the distinct sensation that the attitude and heading indicators were out of whack. I could *see* we were straight and level, but the instruments were showing about a 30-degree bank. After cross-checking with the other instruments, my brain snapped back into synch as I realized we really were in a turn.

Among the things we learn in pilot training are the many visual and vestibular illusions that can occur. Flying in haze causes the illusion of being farther away, so we tend to shallow our approach and land long. In rain, refraction makes it appear that we're too high, thus we tend to descend below glide slope. Acceleration of the aircraft creates the illusion that the aircraft is pitching up, and we tend to pitch the nose down in response. If that occurs at low altitude — such as when taking off in low ceiling conditions — we are likely to collide with obstacles on departure. Not a pretty picture.

Nighttime brings a whole other set of illusions into play. At night, staring at a fixed position light can make it appear to move. Consistently spaced lights can create the illusion of a false horizon. An airport surrounded by unlighted terrain can make us appear to be higher than we really are, causing us to descend too early on an approach. But there are other types of "illusions" that can occur in flight — things we see that tell us a story that isn't exactly correct. And like the visual illusions we learn about, these illusions can trip us up and sometimes put our safety in jeopardy.

A friend of mine was flying a Piper PA-28 Archer eastbound along the New Jersey/New York shoreline bound for southeastern Connecticut. He was about 10 miles off shore, talking with ATC, intending to overfly John F. Kennedy International Airport when his oil pressure light illuminated. This undoubtedly concerned him, not wanting to swim on this particular afternoon. He reduced power to help keep the engine going, headed straight for the airport, and said a silent prayer before alerting ATC to his situation. If the engine could keep running just long enough to get him to shore, he would be okay.

ILLUSTRATION BY BRANDON JACOBS

Not long afterward, while scanning his instruments, he saw that his attitude indicator was acting lazy. What were the chances? An engine failure followed by an instrument failure? But as he maintained his scan, he noticed that his oil temperature wasn't increasing as one would expect as the oil pressure drops. It slowly dawned on him that something was amiss with the warning lights. As it turned out, a mechanic had unwittingly switched the position of two warning lights. So the warning light that showed up as oil pressure really should have been illuminating the vacuum failure warning light.

Even when everything is wired properly, we can get indications that seem to point us in the wrong direction. Years ago, a flight instructor who worked for me had some excitement while giving an aircraft checkout to a student in a Piper Turbo Arrow (PA-28RT-201). A few minutes after departure while climbing toward the practice area, the engine began to run rough. In response, he had his student put the fuel boost pump on "high." The engine roughness smoothed out, but they started a turn back toward the airport to figure out what was wrong. Not long after that, white smoke smelling of burning plastic came wafting into the cockpit. Obviously it was an electrical fire, so following prescribed procedures, they turned off the battery and master switches to de-energize the electrical system.

There are other types of "illusions" that can occur in flight — things we see that tell us a story that isn't exactly correct. And like the visual illusions we learn about, these illusions can trip us up and sometimes put our safety in jeopardy.

At this point, they were entering the pattern, and it was time to get the landing gear down, which they promptly accomplished. The tower confirmed that the gear was down and "appeared locked" and gave them permission for landing. That was about the time that the engine stopped running. Fortunately, the instructor was able to dead stick the aircraft to a safe touchdown on the runway, and they managed to get out of the aircraft as smoke and flames rolled out of the engine compartment.

As it turns out, the instructor and his student had done the right things, but the indications had been misleading. The engine roughness was a result of a crack in a fuel line, which prevented adequate fuel from reaching the cylinders. So turning the boost pump on "high" kept the engine going by forcing enough fuel through the fractured fuel line to the cylinders, but it also resulted in spraying raw fuel into the engine compartment.

The turbocharger, hot as can be during the climb, ignited the spray of fuel, starting an engine fire. The white smoke wasn't from any wires burning — as one would expect— but was from the scat tubing that was being consumed by the flames. The white smoke was flowing in through the cabin air and cabin heat vent. When the pilot turned off the electrical master, the boost pump shut off, and the raw fuel no longer sprayed into the engine compartment. That slowed the engine fire, but it also meant the engine would quit.

The retractable nose gear retracts the wheel into a well right up under the turbocharger — where the fire was beginning to rage. Fortunately, extending the landing gear got the tire out of the fire zone before it melted. Otherwise the nose wheel would likely have become seriously damaged, making the landing and rollout a bit more demanding.

So, the pilots did the right things — according to the emergency procedures — but for the wrong reasons. The indications the pilots received led them to the wrong conclusion about what was going on, but it happened to work out okay for them. It would have been easy to fool themselves into thinking all was well when the boost pump smoothed the engine roughness, but even a minute delay in turning back could have changed the outcome dramatically.

Fast-forward to a scenario last year when I was attempting to complete a short flight under VFR conditions. The sky was punctuated with cotton ball clouds, and I found myself weaving through them to maintain the required cloud clearance. As I spiraled and descended, I suddenly realized I had no ground references. Remembering the lesson from years ago, I cross-checked my instruments and took in the reality of the situation. I had seen this trick before — my actual attitude didn't match what my eyes and vestibular senses were telling me.

Many situations can occur in flight where the information provided by our eyes and vestibular senses can create a powerful illusion that conflicts with the reality. Even if we've learned about them before, or experienced them firsthand, we are never immune to their trickery. But the more we learn, and the more we practice, the less likely we are to fool ourselves in flight. EAA

Even if we've learned about them before, or experienced them firsthand, we are never immune to their trickery. But the more we learn, and the more we practice, the less likely we are to fool ourselves in flight.

Robert N. Rossier, EAA 472091, has been flying for more than 30 years and has worked as a flight instructor, commercial pilot, chief pilot, and FAA flight check airman.

The Nondirectional Beacon

Your grandfather's navigational aid

BY JEFF SKILES

IN RECENT MONTHS I have written about several different navigational aids now long relegated to the annals of aviation history. I really hadn't intended to do a series on the subject, but one thing led to another and I ended up writing columns about the lighted airway system, the four course range, and the visual aural range. All of these are long gone today, of course, but one pioneering navigational means is still very much among us: the nondirectional beacon (NDB).

The nondirectional beacon is a simple enough device, and its entire operational function is represented in its name. It broadcasts a signal, and unlike most other navigational aids there is no directional component whatsoever. NDBs use the low-frequency range of the radio wave spectrum typically broadcasting on 190-435 kilohertz. This is just below the AM radio band thus allowing innumerable pilots of yesteryear to tune in airborne entertainment in the days before XM radio.

The reception range of a particular station is dependent on a variety of factors, not the least of which is the power that is brought to bear. A low-power station might be useful as a localizer beacon to identify the outer marker of an ILS. High-power NDBs are more suitable for long-distance navigation. Across the largely empty plains of Canada a combined VOR/NDB airway can extend for hundreds of miles. The NDB, and VOR are co-located at either end of the airway. The very-high-frequency VOR will set you on course for the first 40 miles or so and pick you up on the other end, but it is useless in the middle reaches of the airway. The intervening miles are flown by tracking to or from an NDB.

RADIO DIRECTION FINDER

While the NDB itself hasn't changed much over the years, the onboard equipment to receive the signal and interpret its meaning has evolved greatly. The early receiver was called a radio direction finder (RDF). The RDF used a mechanically operated loop antenna that would project from above or below the cockpit. Looking like a vertical basketball hoop it could be cranked around until a null was detected (minimum aural signal); the azimuth position of the antenna could then be read as a bearing to the station. Two such bearings or better yet three could be plotted on a chart and fix the position of the airplane. The actual plotting of the azimuth bearings must have been problematic in an airline cockpit, though. The DC-3 hardly boasted a steamship-sized chart table.

AUTOMATIC DIRECTION FINDER

The introduction of the automatic direction finder (ADF) significantly improved conditions by displaying a continuous bearing to the station with reference to the nose of the aircraft. This real-time information allowed the NDB to be useful for instrument approaches.

Because both NDB transmitters and ADF receivers are fairly cheap to buy and maintain, NDB approaches consequently proliferated. The NDB approach falls into the category of nonprecision approaches, although many would argue that the word precision, non or otherwise, belongs nowhere in the name. However, with appropriately high minimum descent altitudes and limited distance between the fix and the field, the NDB brought all-weather capability to many small airports. Even today NDBs are liberally strewn across the sectional chart in some areas of the country.

Automatic direction finder and control panel

THE NDB APPROACH

Without going into extensive detail, an NDB approach is conducted by comparing the aircraft's heading with the bearing to the fix displayed on the ADF card. Instrument students learn that one must "track" to the station in the same manner as we crab into the wind on final approach to a runway. For instance, if the course to the station is 270 degrees, and the wind is from the south, one might fly 265 degrees crabbing into the wind and expect to see the ADF needle pointed 5 degrees to the right of the nose. After station passage one would conversely expect the needle to point 5 degrees to the left of the tail. If the stars are in alignment, the appropriate wind correction should place the aircraft on the prescribed approach course.

RADIO MAGNETIC INDICATOR

Since all this was done by comparing the heading on the directional gyro with the bearing on the ADF card, further improvement was envisioned by combining both into one instrument. This was called a radio magnetic indicator (RMI), and the RMI alleviated much of the mental gymnastics required to successfully hold a course.

NDBS ON THE AIRLINE

When I first began flying at the airline 30 years ago we still had ADFs installed in the jet, albeit the fancy ones with an RMI readout. Because NDB approaches were still listed in our airline's ops specs, we needed to demonstrate them on checkrides, too. A full procedure turn was part of the drill as well, and being "nonprecision" there was no glide slope, calculated or otherwise. We would "dive" the three-holer (Boeing 727) to the minimum descent altitude and "drive" to the missed approach point. All very old school. If the sim instructor was feeling particularly Machiavellian, the approach might be conducted with an engine out as well.

I would generally throw in a few degrees of left correction to account for a crosswind and hope for the best. The crosswind in these early sims always seemed to be 10 knots from the left. At 140 knots or so you arrived at the missed approach point too fast to get significantly off course. But, we still used to joke that the acceptance of an NDB approach on the line really needed to be accompanied by the declaration of an emergency given how rarely we conducted them.

NDB AT CLEVELAND

Every six months we would accomplish our requisite NDB approach in the simulator with no further exposure on the line. But, even for an airline pilot, a steady diet of ILS approaches can't always be guaranteed. There was a period of time about 25 years ago when the ILS wasn't in operation for the northeast runways in Cleveland. If memory serves it had something to do with runway construction or resurfacing. This unfortunate occurrence coincided with a month of trips for me to the city by the lake. It always seemed to be my leg to Cleveland; I think the captain carefully planned it this way. For the first three weeks of my Cleveland assignment Indian summer weather placed the field in clear view from minimum vectoring altitude leading to uneventful arrivals. The fourth week however, my luck ran out!

The ATIS advertised low clouds and poor visibility. The disembodied controller's voice cheerfully proclaimed that we should expect the NDB. Grrrr. At least the approach radar worked and we could get radar vectors onto final. The wind wasn't particularly strong, and I configured early. Approaching the fix my eyes rarely left the RMI as I watched expectantly for the needles to flip from intently pointing off the nose to somewhere behind the tail. My plan was to descend rapidly to the MDA and hopefully get the runway in sight for a visual before this all got too far out of hand. The needles flipped. I started the clock to time the segment to missed approach and focused like a laser on the 060 heading on the RMI. At our airspeed we would need a 700 fpm descent rate to get down to MDA before the missed approach. I opted for 1,000 to get down early and hopefully have a little more time to look around. Fortunately, just as I was bringing up the power to level out at minimums, we popped out of the deck with the runway in sight over the nose, thus successfully ending my first and only "for real" NDB approach in a transport category airplane.

I believe others with considerably higher standing on the airline's organizational chart may have held a similar antipathy for NDB approaches because shortly after this experience, they were mysteriously removed from our ops specs negating the need for testing or practical application. I haven't shot an NDB approach since.

Certainly within the coming years GPS will render the lowly NDB obsolete. In fact, other than CAT II and III precision approaches, possibly all instrument procedures will be defined solely within the digital memory of our onboard GPS receivers. But, the NDB has served proudly for the better part of a century safely guiding aircraft to their eventual destinations and deserves a place of honor as certainly the longest lived navigational aid extant. EAA

Jeff Skiles, EAA Lifetime 336120, can be reached at *JeffreyBSkiles@gmail.com*.

HAND MADE

& HAMMERED OUT

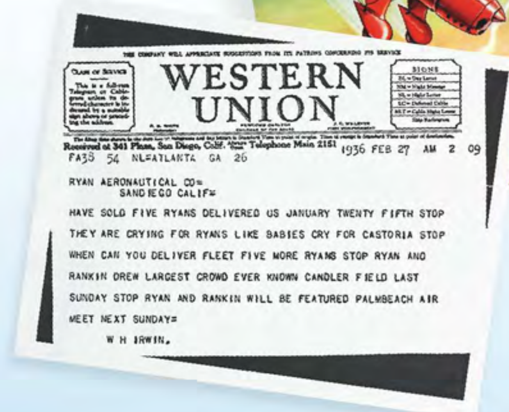
TED TEACH'S STUNNING RYAN SPORT TRAINER

BY SPARKY BARNES SARGENT

THIS SPLENDID 1936 RYAN SPORT TRAINER stopped countless passersby in their tracks as it shimmered under the sun in front of the VAA Red Barn at EAA AirVenture Oshkosh 2016. NC14985 is a pristine reflection of the golden age of aviation, and a tribute to the enthusiastic passion and knowledge of a handful of men who poured their life energy into a flying machine with such zeal that they imbued an inanimate object with priceless animation.

PHOTOGRAPHY BY TYSON RININGER


CLICK THIS VIDEO
TO SEE MORE ABOUT TED TEACH'S RYAN ST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HAVE SOLD FIVE RYANS DELIVERED US JANUARY TWENTY FIFTH STOP THEY ARE CRYING FOR RYANS LIKE BABIES CRY FOR CASTORIA STOP WHEN CAN YOU DELIVER FLEET FIVE MORE RYANS STOP RYAN AND RANKIN DREW LARGEST CROWD EVER KNOWN CANDLER FIELD LAST SUNDAY STOP RYAN AND RANKIN WILL BE FEATURED PALMBEACH AIR MEET NEXT SUNDAY=

W H IRWIN.

Owner Ted Teach, EAA 36640, of Dayton, Ohio, fell in love with Ryan STs at an early age. He learned to fly when he was a teenager and went on to become an aeronautical engineer. Ted's aviation avocations include competitive model building and flying, competitive sailplane soaring, corporate aviation, and restoring and flying antique airplanes.

Above: *Cover of* Popular Aviation, *November 1934 issue, features the new Ryan ST.*

A telegram which W.H. Irwin, who was the first to purchase NC14985, sent to the Ryan Aeronautical Company in February 1936 (excerpted from Ryan School of Aeronautics Sky News, *March 1936).*

ST PROVENANCE

T. Claude Ryan achieved international fame after building Lindbergh's *The Spirit of St. Louis* in 1927. In 1934, Ryan and engineers at Ryan Aeronautical Company designed and built the first Ryan Sport Trainer in San Diego, California. The ST's streamlined, oval monococque metal fuselage signaled a departure from commonly used tube-and-fabric construction. Bearing some similarities to the P-26 Peashooter and the Gee Bee racers, the ST cost $1,000 to engineer, and the project was finished in nine months including design, building, test flight, and certification.

After production began, the ST caught the eye and imagination of W.H. Irwin (a southeastern automobile distributor) who represented Air Services Inc. at Candler Field in Atlanta, Georgia. In early 1936, Irwin ordered 15 Ryan Sport Trainers, and shipments began with a four-ship formation that left San Diego on January 24. Two 125-hp models were included in the first delivery along with one 95-hp model.

The latter ship was likely NC14985; aircraft records show that the Menasco B-4 powered ST was purchased by Irwin on January 22. It was sold to Laurence August Schmarje of Florida in August 1936, and changed hands numerous times until 1997.

"My mechanic and friend Doug Smith saw the Ryan advertised, and I went to Santa Paula and bought it," Ted said. "The Ryan had not been flown during the five years since its latest rebuild. Initially, I was going to fly it home, but I talked to mechanics Al and Brad Ball and decided to leave the Menasco engine with them in California for a major overhaul. We trucked the Ryan to Ohio."

When Ted returned to Santa Paula to pick up the freshly overhauled Menasco engine in 1998, another temptation arose. There was a 1930 prototype Waco INF on the field, and it needed a new caretaker. Ted couldn't resist, and the INF beguiled him into putting the Ryan ST in the back of the hangar — for nine years! But right after the INF flew home from EAA AirVenture Oshkosh 2006 with its Silver Age Bronze Lindy, the Ryan took center stage.

Doug, who at one time was on a pathway to become an airline pilot, discovered years ago that his real passion was aircraft restoration, with a yen for excellence in all that he does. He has worked on several award-winning restorations, including Ted's Mooney Mite, Pitts Special, and Waco INF.

PHOTOGRAPHY BY **TYSON RININGER, SPARKY BARNES SARGENT**

The primary restoration trio: WWII veteran Bob Jacoby, owner Ted Teach, and mechanic/master craftsman Doug Smith.

The Ryan Sport Trainer is beautiful from any angle; its ailerons, rudder, and trim tabs are cable operated.

STRIPPING THE AIRFRAME

Doug and Ted rolled up their sleeves and set about removing the Ryan's fairings and the cowling, which were not in the condition they desired. They left the fuselage itself intact. "I believe the fuselage, from the rear cockpit bulkhead aft, has its original skin because of its rivet style," Doug said. "We stripped all of the paint from the inside of the fuselage with a water-based, noncorrosive paint stripper and then painted epoxy-primer inside, followed by silver polyurethane in the cockpit area."

Old parts were saved for patterns, and individuals with metal forming experience were found to form the Ryan's complex, curvaceous parts. The wing root fairings were made by highly skilled Mark Kennison and Steve James of D&D Classic of Covington, Ohio. Doug spent a fair amount of time with them, assisting but primarily watching and learning metal forming techniques.

When Doug removed the fabric from the wings, he realized that a bit more work was in store. "The wings have a wood spar with aluminum ribs, and the ribs had been damaged and repaired, but all of the scarfing had been done on the tops of the ribs with round rivets," Doug said. "I removed all of those repairs and then made repairs on the underside of the ribs with flush rivets, so now the ribs are smooth."

The wings and empennage were then covered with Ceconite C-102 fabric and the Air-Tech Coatings system.

This Ryan Sport Trainer flew home to Ohio with the 2016 Antique Grand Champion Gold Lindy award.

Ted Teach with his Ryan ST fuselage during the restoration.

Steve James of D&D Classic, forming a complex, curved wing root fairing.

Note the precision fit of all the formed metal cowling and fairings.

The Ryan's front cockpit.

WHEELPANTS

The Ryan's intricate wheelpants consist of front and rear sections. The front is composed of a three-piece dome that is riveted together. Doug disassembled them and smoothed out the metal with an English wheel and planishing hammer. When he stripped the paint from inside the domes, he found a pleasant surprise — the imprinted part number from the Ryan factory was still there.

Talented metal shaper Brian Stansberry of Moulton, Iowa, worked on the landing gear fairings and the engine cowling. "We took our entire landing gear assemblies to Brian," Doug said. "I made a mock-up bottom wing jig so I could hang the landing gear from it and have full range of motion, because the lower fairings telescope behind the upper gear fairing as the landing gear extends and retracts on takeoff and landing."

MOLDS AND FAIRINGS

Patience is certainly a virtue when it comes to aircraft restoration. "It's a long process to go from making the model of the part that you want, to creating the molds so that you can make the actual part," Ted said. "Doug made 24 molds in order to make all the covers for the flying and landing wires, rudder fairings, oil access door, fuel neck filler fairing, nose bowl doublers, and cowling doublers. The fairings that mounted on the rudder were quite special and were the most complex. We took the drawings, rudder, and station measurements to a friend who converted it all into digital data, which was then put into a CNC milling machine. He glued together enormous blocks of wood that were hollowed out to the shape of the rudder fairing, and then we laid aluminum sheets in the blocks and formed the fairings."

It was a tedious process that took nearly six months, since the rudder fairings had to mate precisely with the fuselage. "The fuselage is a tapering ellipse, so we calculated at the hinge line of the rudder what would be the maximum diameter of the curve that had to fit inside the extension of the fuselage," Doug said. "The rudder fairings articulate so that at full rudder deflection, a gap never opens up between the fuselage and rudder. After forming the first set of rudder fairings, we discovered they were 1/4 inch too deep and didn't allow any clearance between the fairing and the fuselage. So we took the molds back down to our friend, and he propped up the leading edge with a 1/4-inch shim and then ran the CNC program again, removing 1/4 inch of material at the leading edge down to zero at the trailing edge. I took those molds back to the shop and hammered out another set of fairings, which fit just right."

ONE RARE RYAN

Manufactured under Type Certificate 541, NC14985 (serial No. 117) originally had a 95-hp, four-cylinder inverted inline Menasco B-4. One of only five Ryan STs built, a Repair and Alteration Form dated November 1943 records a model change from an ST to an ST-A when a 125-hp Menasco Pirate C-4 was installed.

"It's such a unique airplane, and we recognize it as an original ST, because the ST's structure is different from an ST-A," Ted said. "The ST has longer flaps that protrude into the stub wings, a hand-cranked flap mechanism, and a tail wheel strut which uses a bungee cord arrangement instead of the spring."

CHALLENGES

Speaking of flaps, Doug said, "The ST's flaps are actuated with a crank, bicycle chain, geared sprockets, and a worm gear on each side that extends the flaps. It takes 30 revolutions to get the flaps down. Before I disassembled the flap mechanism, I took photographs so I would know how it all went back together, but after I reassembled it, I couldn't get the flaps to work. I discovered that the mechanism hadn't been installed correctly during the previous restoration."

Fortunately, one of the Ryan's previous owners, Ev Cassagneres, was alive at the time and able to provide the solution. "Ev was a retired draftsman and Ryan historian," Ted said. "Ryan allowed him to copy the factory drawings. Ev also had nearly 100 original factory photos, Ryan books, and personal knowledge along with a willingness to share this information with us."

One of those photographs revealed the correct routing of the intricate flap mechanism. "There are aluminum idlers that route the chain underneath the torque tube, back up and around another set of idlers, around the gear crank, and then out to the flaps," Doug said. "Then there's a spring that attaches to the bottom of the fuselage that holds tension on the whole system. So I replicated that in the airplane, and now the flaps work just fine."

Another challenge was purely physical and required quite a bit of flexible dexterity. "I stood on my head a lot through the whole project," Doug said with a smile. "There's no side panel to provide access to the firewall, and the fuel tank is right behind the firewall. So you have to get down into the seat and turn with your feet up in the air to work on anything on the back side of the firewall!"

PHOTOGRAPHY BY SPARKY BARNES SARGENT

Doug Smith carves Styrofoam to the desired shape for the flying wire fitting.

Just a sampling of the fairings in progress for the flying wire fittings.

Doug Smith and Bob Jacoby making sure the fairings fit precisely to allow for gear travel.

Look at the detail on the complex landing gear fairings and wheelpants!

Close up view of the Ryan's neatly faired empennage.

Close up view of the rudder fairing while the rudder is deflected.

FORMING FAIRINGS

When Ted bought the Ryan, it didn't have any of the fairings for the flying or landing gear wires. So he and Doug took a methodical approach to making some by first outlining the basic shape on the wing and then carefully measuring specific locations to determine angles of contour. Then a piece of Styrofoam was carved to shape — but the real conundrum was figuring out how to make mirror images of the fairings for the other side of the airplane.

"Ted had an idea of how to derive the precise mirror image," Doug said. "I took my Styrofoam block, mounted it on a piece of poster board, and cut grooves through the block at 1-inch stations. Then I took graph paper and inserted it in each groove until it hit the poster board. I drew a line tracing the contour of that station on the paper, removed it, and flipped it end-for-end to obtain the mirror image. I cut that graph paper out and transferred the shape to red construction paper, which I glued onto 1-inch Styrofoam, and sandwiched it all together."

Then, Doug carefully carved and sanded the Styrofoam until the red construction paper appeared. "When all of the construction paper became visible, we had the exact mirror image," Doug said. "The next step was mounting the male molds to a piece of MDF wood. After I smoothed out the radiuses with Bondo, I was ready to pour the female. I sandwiched several layers of the MDF over the male and then poured liquid fiberglass resin, reinforced with chopped glass, over the male mold. After the resin set, I then had a female mold in which I could hammer-form the aluminum to create the fairing."

The next task was deciding how to cut holes in the middle of the fairings. Doug laid the wings on sawhorses, and with clamps and 2-by-4s, rigged them with 4-1/2 degrees of dihedral. "I used a No. 30 drill bit and guessed at the first hole location. Then I attached string to the flying wire attach points," Doug said. "Wherever the string was touching the fairing, I used a little rat tail file to open up the hole until there was clearance around that string. That gave me the exact location of where the wire would be, so I could enlarge the hole precisely without making it too big. I didn't want to use a step drill, because that would really deform the curved surface of the soft aluminum fairing."

Anyone who has ever worked on airplanes knows how handy it is to have the correct tool for specific jobs. So, as was often the case during the restoration, Ted headed back to the full machine shop in his basement to fabricate yet another customized tool for the task at hand. "Ted made a special nibbler that allowed me to very slowly and accurately nibble the rest of that aluminum out of the fairings," Doug said with a smile.

Ryan Sport Trainer NC14985 General Specifications

(as powered by the 125-hp Menasco Pirate C-4)

Length:	21 feet, 6 inches
Height:	6 feet, 11 inches
Wingspan:	29 feet, 11 inches
Wing area:	124 feet
Wing chord:	56 inches
Airfoil:	NACA-2412
Weight empty:	1,027 pounds
Useful load:	565 pounds
Gross weight:	1,600 pounds
Fuel capacity:	24 gallons
Oil capacity:	2.5 gallons
Max speed:	150 mph
Cruise:	120 mph
Stall speed with flaps:	42 mph
Stall speed no flaps:	45 mph
Range:	250 miles
Takeoff run:	525 feet

(Derived from Carpenter, Juptner, and owner Ted Teach)

RESTORATION PHOTOGRAPHY COURTESY OF **DOUG SMITH**

PHOTOGRAPHY BY **JIM KOEPNICK**

FRIENDLY RESOURCES

At times, the decade-long project seemed insurmountable, but persistence prevailed, thanks to helpful folks and surprisingly plentiful resources along the way. "Fred Barber of Kansas City, Missouri, knows almost everything about Ryans, and he supplied copies of service bulletins for the Ryan and Menasco engine," Doug said. "He also made several parts for us, and we became great friends with him and his wife, Nancy. When we got stuck, it was a phone call to Fred, 'What do we do now?'"

One such occasion involved having the rudder and its fairings attain the correct degree of deflection per the drawings. Doug studied all of the Ryan documents, but all he could find simply stated that the rudder stops were set at the factory. Lo and behold, upon close examination, there were no rudder stops in NC14985. But Fred had a set, which he readily lent so that Doug could make some.

Another puzzle was the absence of witness marks from previous holes where the rudder stops should have been mounted in the cockpit. "The front cockpit forward had been reskinned at some point due to damage, and the rudder stops had not been reinstalled," Doug said. "So Fred's knowledge was extremely helpful in making this airplane not only correct, but safe."

Along the way, many others contributed to the restoration in various ways including Kenny Blalock of Special Products Aviation in Conway, Arkansas, and the late Jack Tiffany and Herman Leffew of Leading Edge Aircraft in Spring Valley, Ohio.

POLISHED TO PERFECTION

When it came time to tackle a few other tasks that required a helping hand, as well as making sure the Ryan was polished to perfection, Doug enlisted the help of Bob Jacoby. A World War II and Korean War veteran, Bob was stationed in Guam and Saipan as a crew member on B-17 bombers and OA-10 Catalinas performing air-sea rescues, and was also a crew chief on P-47 Thunderbolts.

The timing was providential; 87-year-young Bob had recently lost his wife and needed a new direction. "Doug and Ted brought me back to life, and I've been having a ball! I experienced flying in the military about 45 years ago, but I didn't realize how much I had forgotten," Bob said, eyes twinkling. "It all came back! I've enjoyed working on the Ryan; we've had a great time, and I've been blessed."

After Doug worked out the hammer marks in the formed metal as best he could with an English wheel and planishing hammer, it was time for the arduous sanding process. "We started out with regular 400 grit sandpaper wrapped around a wood block to get the peaks and valleys out, and once we got to 800, we just started using our fingers as we worked our way up to 2,000 grit," Bob said.

> **It is *fun* to fly.**
> **No question about it.**
>
> ***Ted Teach,***
> *owner/pilot/restorer*

COZY COCKPITS

Pilot and passenger sit in cozy comfort on newly upholstered black leather seats in the Ryan's snug cockpits and are shielded by Plexiglas windscreens. "The windshields were formed by a friend of mine, Jeff Rogers of Airplane Plastics, who makes canopies for several airplanes including RVs," Ted said. Up to 40 pounds of baggage may be carried in a compartment between the cockpits.

The instruments are mostly original to the era and were overhauled by Air Parts of Lock Haven, with the exception of a modern radio, transponder, and cylinder head temperature gauge. A three-in-one gauge for the oil pressure, fuel pressure, and oil temperature was overhauled at Legacy Aircraft Instruments in California.

COME FLY WITH ME

Ted flew the Ryan ST for the first time on June 25, 2016. It had been 37 years since the ST had last flown. Like many antiques, the ST has its own demanding personality. "You're constantly flying it; you have to stay on it with your hands and feet," Ted said. "To find out what its stalling characteristics were, I simply pulled the power back, held the stick all the way back, and waited. It just kind of broke, so the next time I held it until it broke a second time, which was a little more sharp. Then I did a series of three, and it just went easily nose down."

The Ryan's landing gear has air-oil shocks to cushion ground operations, and Ted said, "It feels like a land lover on takeoff, and if you hit the least little bump, it kind of wobbles down the runway because the gear is soft, so you just have to be careful about keeping it pointed straight ahead. The cockpit is extremely close and tight for me at 190 pounds. One of the awkward things is that there's not a very good place to have someone put their feet to stay off the rudder pedals in either cockpit."

Regardless, Ted proclaimed with a boyish grin, "It is *fun* to fly. No question about it. It'll climb at 700 fpm with just me in it, so that's really great for a 125-hp engine. Then when you get ready to land and flare, it doesn't want to come down!"

RYAN REWARDS

The restoration wasn't simple, and it wasn't easy, but the results are simply easy on the eyes. NC14985 is aptly perched on the shoulders of modern-day aviators who still possess a wealth of knowledge regarding this golden age monoplane. It was handmade and hammered out at the Ryan factory in 1936, and was lovingly restored by very similar methods and techniques in Ted's hangar (albeit aided by modern technology).

Ted chuckled and shared that one of the most rewarding aspects of the restoration is, "Looking at it sitting there in front of the Vintage Hangar! And I feel like it may be the most photographed airplane at this show. You know, there's something about that ST — some of us older people call it sex appeal; it just has that 'look at me' attraction!"

No wonder the Ryan ST has been the apple of his eye since Ted was a little boy. "It was Claude Ryan's concern for beauty of line and for perfection of each small detail that made the ST one of the handsomest airplanes in the sky," Joseph Juptner wrote in *U.S. Civil Aircraft*.

Ted, Doug, Bob, and others brought that same degree of attention to detail throughout the restoration. NC14985's scintillating presence is the embodied expression of their exquisite craftsmanship. Their efforts were lauded by the AirVenture judges, and Ted's Ryan ST flew home as the 2016 Antique Grand Champion Gold Lindy winner. (Sadly, Bob Jacoby died five months after AirVenture.) EAA

Sparky Barnes Sargent, EAA 499838, holds a commercial glider certificate with private single engine land and sea ratings, and she personally restored her 1948 Piper Vagabond.

Adventurous AirCam

THE STORIED HISTORY BEHIND THE VERSATILE AIRCRAFT

BY HAL BRYAN

PHOTOGRAPHY BY **ERIN BRUEGGEN**

CLICK THIS VIDEO

TO SEE MORE ABOUT THE AIRCAM

"I might as well have been in outer space, because if my equipment failed, I wasn't coming home," said Phil Lockwood, EAA 211596, describing flying the prototype AirCam over an African rainforest in 1993. Phil wasn't exaggerating — he was routinely flying low over an incomprehensibly dense ocean of trees in areas that would take rescuers weeks to reach on the ground. That's assuming, of course, that there were any rescuers to call in the first place.

There weren't.

The Man

Phil, the Lockwood of the Lockwood Aircraft AirCam, is a genial guy with a quick and infectious laugh that seasons every conversation with a pervasive enthusiasm. Behind that laugh is the sharp mind of an inventor who's always looking for an outlet among his myriad interests.

"I was always interested in a whole bunch of different things, from photography to airplanes to boats to cars to designing houses," he said. However, airplanes didn't really top that list until he was a teenager, during the family's annual summer vacation in the Adirondacks. In 1975, when Phil was 15, he got a ride in a seaplane. Before that flight, Phil's first love was boats.

"We lived in a town that was a river town," he said. "I just loved the water, loved boats — we had a boat. I took care of it and learned how to run it." So, it was fortuitous, maybe, that his first flight was in a seaplane, sitting in the right seat of a Cessna 206, intrigued by the pilot's every move.

"I watched him advance the throttle and saw the floats start to come up on the plane, and I could recognize that from a boat and from water-skiing," he said. "I saw him rotate off and we left the water, and then I got to see the lake and the area from a different perspective."

That change of perspective, as it so often does, made a big impact. "One of the things that amazed me the most was being able to see the shallow spots," he recalled. "It was a really cool experience."

After that flight, Phil followed a typical path and started getting into model airplanes, and then, when he was a junior in high school, he realized it was time to decide what he was going to study in college. At first, the choice seemed clear; despite his budding passion for aviation, he was sure that he wanted to be a marine architect. Then he had an unusual flash of insight.

Phil Lockwood

The AirCam's new optional cockpit enclosure enhances an already extremely versatile airplane. It's extremely light, and can be installed or removed easily by one person in just a few minutes.

"Most of the adults that I knew at that time kind of lived for the weekends," he said. "They *had* their job, but they didn't seem to really *enjoy* their job." Phil couldn't bear the thought of his passion for boats waning if he did it for a living, so he made a conscious decision to go after what he described as the second most interesting thing to him at the time.

"I'm going to go into aviation and keep boating as my fun thing," he said. "And, hopefully, I'll keep liking airplanes." Phil chose the Florida Institute of Technology and dove headlong into its Air Commerce and Flight Technology program. By 1982, after four years at FIT, he'd gotten his certificates and ratings, and learned a lot about the business of aviation along the way.

"I've used everything I learned," he said, then added with a laugh, "I wish I'd have paid more attention."

After college, Phil, with just a hint of irony, went to work selling boats at a local marina.

"I did boat sales ... for maybe six months, and then I got a job with a little company called MaxAir." MaxAir was the home of the Drifter, an early ultralight kit. Available as both a Part 103-legal ultralight, powered by a Rotax 277 or a two-seater with a Rotax 503, or, later, a 912, the tandem taildragger was displayed at Oshkosh in 1982, then went on sale the following year.

"At that time, in the early '80s, the ultralight industry was booming," Phil said. "I thought this is an industry that could use some professionalism; it's growing, it's kind of raw, it's kind of cool." Phil signed on as the company's director of marketing, but, like most lean operations, at MaxAir it was all hands on deck so Phil got his hands dirty on the technical side as well.

"My dad was an engineer, so I kind of had that natural technical ability," he said. "And my mom was a very social person, and I kind of got her personality and his technical side."

There's another side to Phil as well: the adventurous one.

The Mission

Des Bartlett was an Australian who originally wanted to be an aircraft designer, having published the plans for a fighter called the Bartlett Bullet in 1944 when he was 17. Then he read a book called *I Married Adventure* by Osa Johnson, detailing her travels through Africa with her husband, Martin, in a pair of Sikorsky flying boats. (See "Sikorsky S-38 to Fly Again," *Sport Aviation,* February 1995.) That set Des on the path to become, along with his wife, Jen, one of the most highly regarded and prolific wildlife filmmakers in history.

In the early 1980s, the Bartletts were looking for an easy way to incorporate more aerial photography into their nature documentaries, so they reached out to MaxAir.

"They needed a simple airplane that they could maintain and operate themselves, and shoot from," Phil said. They bought two Drifters, and then they asked what would prove to be a fateful question: Would Phil come to Namibia to help?

At first, Phil's colleagues at MaxAir weren't, as he put it, "super happy" with the idea of him spending six weeks in Africa, but eventually they saw the opportunity and gave their blessing.

"I just had a blast," Phil said. With this trip to Namibia, he forged a partnership that lasted until Des' death in 2009. Phil, who counted photography among his passions just after boats and airplanes, reveled in the opportunity to look over the shoulders of the pair of award-winning filmmakers.

"We would do really cool things that you just couldn't do without that airplane," he said. The Drifters enabled the Bartletts to find herds of desert elephants, a real challenge given that the animals were always on the move, roaming between food and water supplies across territory spanning hundreds of miles. They would spot the herds from the air and then fly back to their base camp, using the animals' speed and direction to plot where they'd be later in the day when the light was right for filming.

Phil returned to MaxAir but continued to support the Bartletts extensively, returning several times during their staggering nine-year production of what would become an acclaimed National Geographic Society film titled *Survivors of the Skeleton Coast*. The Bartletts mentioned Phil's name to a colleague, a renowned photographer named Michael "Nick" Nichols. Nick contacted Phil almost immediately.

PHOTOGRAPHY BY **ERIN BRUEGGEN**

Phil enjoying a rare chance to fly from the front seat during a photo mission over the Republic of Congo.

"Hey! We got this really cool project in north Congo," Phil remembered Nick saying. "We're going to be flying over the Ndoki rainforest, and it's really remote — we need some Drifters." With MaxAir having recently gone out of business, Phil was intrigued by the opportunity. That is, until he started asking some basic questions.

Are there any airstrips in the area? No.

How far will we fly? A hundred miles or so out over the rainforest.

What's the chance of rescue if we go down? Zero, there's no one to come get you.

"Doesn't sound like the perfect place for a single-engine airplane," Phil said. "I told them I'd been working on this concept for a twin-engine pusher," he said. Phil showed Nick and his team the drawings, and the response was, "Okay, what's it going to take?"

The Machine

What it took was about six months. Phil started work on the prototype in March of 1993, and it was finished in September. Initially, Phil had hoped to simply scale up the Drifter, but he soon realized that the process would be more complicated than that. Reinforcing the airframe to accommodate a second engine added weight, which necessitated a bigger wing and tail section, and so on. So, Phil and his team started over with a clean sheet based on two 65-hp Rotax 582s.

AirCam No. 1 ended up looking, at least superficially, a fair amount like a scaled-up, twin-engine Drifter. It shared the earlier airplane's general configuration: a tandem, high-wing pusher on conventional gear with a completely open front seat. Also like the Drifter, the first AirCam was built around a wire-braced boom tube fuselage, though the AirCam's was larger. Other than the aluminum center section, the wings are covered in Dacron over aluminum ribs with traditional fabric on the wingtips, flaps, and ailerons. A portion of that Dacron is attached using Velcro fasteners to provide access to the engines, and there are zippered inspection panels throughout the wing. The elevator is also covered in fabric, while the rudder is stressed-skin aluminum. The cockpit area is welded chromoly tubing and features dual controls.

Initial flight testing proved the validity of the design. Takeoff roll was just a few hundred feet, and the Rotax 582s enabled the airplane to actually take off and climb on one engine, not just maintain altitude. The economical two-stroke engines gave the airplane considerable endurance as well, sipping less than 6 gallons — total — per hour. Even with the security that comes of redundancy in a twin, Phil added a ballistic parachute, though most of the time the airplane would be flown low enough to make a successful deployment unlikely.

Once the flight test time was flown off, the AirCam was disassembled and put into a half-dozen crates and shipped to Brazzaville, the capital of the Republic of Congo. The team paid $24,000 for three-day shipping, but nobody was surprised when it took three weeks. Phil eventually met up with the airplane and got it assembled and flown into a village called Bomassa where the locals had carved out a 600-foot airstrip along the Sangha River.

UP CLOSE WITH AIRCAM NO. 1

After the second mission to the Republic of Congo in 1994, the AirCam prototype was purchased by the National Geographic Society, which then donated it to the Nouabalé-Ndoki National Park for use in research. During its service with the park, the aircraft was damaged and went unrepaired because of the remote location and the expense involved.

Russ Solsvig, EAA 466754, an airline pilot, bought it and shipped it back to the United States where he completely restored it. Russ later traded it back to Lockwood Aircraft for a new AirCam.

Recognizing the significance of the prototype, Phil donated it to EAA in 2008. It currently hangs proudly just off the main entrance to the EAA Aviation Museum. Because of its central location, the original AirCam that braved the harsh, unforgiving environs of war-torn Congo, is seen by more than 70,000 museum visitors each year.

"All the villagers [were] excited," Phil recalled, "They'd never seen … any airplanes." Obviously, they didn't have any experience building airports, so they asked Phil how they could tell when the runway was smooth enough. His answer was simple and pragmatic: Get in a Land Cruiser and drive along the runway at 40 mph, and "when you're not getting bounced out … it's smooth enough."

Before long, Phil, Nick, and the rest of the team settled into a routine. Situated close to the equator, they were afforded 12 hours of sunlight each day, from 6 a.m. to 6 p.m., so they stuck to a schedule that Phil said made it feel like a military operation.

"We knew that the 'golden hours' were from 6 to 8 in the morning, and from 4 to 6 in the afternoon," he said. "So, we were always up in the air during those two hours."

VIEW OUR AIRCAM FLICKR GALLERY

During those "golden hours," Phil flew while Nick or one of the other photographers shot photos, documenting the rainforest to a degree never before possible. At the time, Nick described the AirCam as "a seat on the edge of the world."

On a typical flight, they'd use the AirCam to spot animals at a watering hole. Phil would climb to a few thousand feet, throttle back, and glide in.

"I would be looking at the light, and I'd say okay, what do you want Nick," Phil recounted. "Then I'd set up the glide ... and we'd get one pass." Nick would shoot photos as they descended, then Phil would add throttle, inevitably startling the animals who would disappear back into the rainforest. With the animals hidden and the lighting conditions deteriorating, they'd fly back to camp, debrief, make another scouting flight or two, then prepare for the afternoon's photo mission. Evenings were spent looking after the airplane and ensuring it was ready to go before sunrise the next day, when the whole process would start again.

The AirCam performed flawlessly, but the mission was not without its challenges. The political climate was one of perpetual upheaval, a fact that made the remoteness of their base camp seem more like an asset than a liability. Fuel wasn't easy to come by, and often stored in suspect containers, so Phil worked out an elaborate double-filtration system and never added new fuel to more than one engine at a time. Navigation was another serious challenge.

"When you look out over that rainforest, there's nothing," Phil said. "There's no landmarks. There's no VORs, no NDBs. [We used] pilotage, and I had a Trimble Flightmate," a GPS with a basic LCD screen that seems impossibly antiquated in a world of iPads and glass, somehow even more so than a paper sectional. But to Phil, it was priceless. He flew without it only once, a short 15-minute hop that found him thoroughly lost after just a few minutes.

"It's a whole different world," Phil said. He made two separate trips to Ndoki, each one lasting about a month, in support of the project. When the shooting was done, the National Geographic Society donated the airplane to the Nouabalé-Ndoki National Park for use in research (see sidebar).

For more about the AirCam's first mission, see "Ndoki — Last Place on Earth" in the July 1995 issue of *National Geographic*, and "AirCam Adventure in the Congo" in the August 1995 issue of *Sport Aviation*.

Out of Africa

"When I got back from that trip, I thought, 'This thing's pretty cool; I've got to build another one,'" Phil said. Unlike the first AirCam, which had been built, tested, and then shipped off to Africa before anyone had a chance to see it, the second airplane made a few public appearances.

"I took it to SUN 'n FUN, I took it to Oshkosh," he said, "and people wanted them." That's when Phil decided to offer the airplane as a kit. "When I saw the enthusiasm when people went up in it and saw it, I said, 'All right, we've got to kit this.'"

"It was a bigger project than I thought it was going to be," he admitted. Phil and his team spent the next five years and 22,000 hours of engineering perfecting the design. "We started shipping wing kits, and then ... tail kits — shipping people the parts as we were finishing that section."

Shortly after the first customer-built airplanes were completed and flown in 1999, Phil made an extremely difficult decision and sold his rights to the AirCam to his business partner, and focused on his aviation supply business for the next several years. Then, in 2007, the opportunity arose for Phil to buy the business back, and he did, just in time for the recession.

"I knew we were headed for something, but I didn't realize it was going to be as long or as bad as it was," he said. "It was a big deal getting the company back up and running." But, thanks to a clear vision, a solid strategy, and, perhaps most importantly, a remarkable team of talented people, he did just that.

People like Gena Tucker, whom Phil hired when the local machine shop where she'd worked for 20 years was shut down. Gena is a professional, sponsored RC helicopter pilot on the weekends, but during the week she's a master welder who works on AirCam kits. And she takes a lot of pride in her work.

Lockwood takes the Village Chief for a trip in the AirCam.

Machinist Jay Wile reviews some of the AirCam's extensive documentation with Phil.

"Every weld that I make, to me, is like signing my name," she said. Take just one look at the crisp and clean freehand welds she makes on, say, an exhaust system, and you'll see that she has a very elegant signature, indeed.

Machinist Jay Wile has been with the AirCam since the beginning, designing jigs and building and assembling just about everything that comes in the crate when you order a kit. He's also deeply committed to quality.

"Make it look good, or don't make it at all," he said. "It's as simple as that." But Jay won't be making things for much longer, at least not professionally, as he's set to retire this spring. Luckily for all involved, he's got an apprentice named Jackson Rushlo, a skilled machinist who, at the age of 23, already has more than four years' experience.

"I don't need to be looking over his shoulder," Jay said. "He knows the type of quality that I want going out the door."

On the engineering side, Phil counts on another young man, a 22-year-old named Justin Smith. Justin's been in love with aviation since he got a flight in an AirCam when he was 12. He started part time at Lockwood at 16, working summers and even paying his own way to Oshkosh to work the booth. He graduated from the University of Florida with a degree in aerospace and mechanical engineering and, along the way, bought a 172 as he finished his private certificate. He planned to get his multiengine rating — unrestricted, for those who are curious — in an AirCam in the spring of this year. And it's clear that he loves the airplane unabashedly.

"The only thing that I can say about the AirCam is you have to fly one," he said. "When you fly it, you just fall in love."

Over the years, the AirCam has evolved to what Phil now describes as the third-generation airplane. The first big change was moving from the boom tube to a more traditional monocoque aluminum skin fuselage. This was done to make the airplane's primary mission — aerial photography — even more viable.

"Whenever you have a boom tube airplane like that in a pusher, you get tail vibration [and] buffeting," Phil said. "It's acceptable from a safety ... point of view ... but it's annoying when you're trying to do photography."

Over time, the new fuselage was strengthened to accommodate the next big change to the airplane: amphibious floats. The 65-hp 582s have given way to the 100-hp Rotax 912 ULS and 912 iS Sport, and the 115-hp 914 UL, which boasts a single engine climb rate of 450 fpm. The original steam gauge panels have largely been replaced by Dynon SkyViews, but both options remain available. Regardless, Phil doesn't spend a lot of energy on avionics.

"The AirCam is not about the panel," he said. "It's about the view."

The most recent addition, inspired by customer demand, is an optional cockpit enclosure. It's extremely lightweight and designed to be retrofitted to existing airplanes, requiring only a slight extension to the vertical fin. It's also easily removable by one person. This adds comfort, versatility, a little streamlining, and, for Phil, sales.

"As soon as we got serious about the full enclosure boom — we started selling in Canada, we started selling kits in Europe, one to Germany, one to Switzerland, one to Austria ... a couple went to Alaska; it's really helped us," he said.

With twin Rotax engines at 100 or 115 hp mounted so close in, it's easy to see why single-engine flight in the AirCam is almost a non-event.

SPECS

AIRCRAFT MAKE & MODEL:	Lockwood AirCam
CERTIFICATION:	Experimental Amateur-Built
LENGTH:	27 feet
WINGSPAN:	36 feet
HEIGHT:	8 feet, 4 inches
MAXIMUM GROSS WEIGHT:	1,680 pounds
EMPTY WEIGHT:	1,080 pounds
FUEL CAPACITY:	28 gallons
SEATS:	2
POWERPLANT MAKE & MODEL:	Rotax 912 ULS (2)
HORSEPOWER:	100 each
PROPELLER:	Warp Drive three-blade carbon fiber composite
CRUISE SPEED:	70 mph
VNE:	110 mph
VSO:	39 mph

What's Next?

"There's nothing I can really talk about," Phil said.

Really? Nothing?

"Cabin heat is one thing I can talk about," he admitted when pressed. Pressed even further, Phil said that they're always working on ways to improve the airplane, to make it safer, stronger, more reliable, more versatile, and, of course, more fun.

Phil estimates that there are roughly 240 AirCams built and flying as of now, an increase of about 100 since he bought back the company in 2007. These days, they're shipping two to four kits per month and build ahead so that they have parts for several kits on the shelves at any given time.

So how does Phil explain the airplane's continuing appeal?

"It really is different from most other airplanes," he said. "It provides a level of satisfaction that is hard to get in another airplane."

Most AirCam pilots today aren't flying research missions over the types of harsh and impassable terrain for which the airplane was built. They're out flying for the purest love of it, enjoying the scenery, dropping in on a grass strip or a lake somewhere simply because they can. Nevertheless, they make those flights knowing that, given its pedigree, the airplane isn't going to let them down. EAA

Hal Bryan, EAA Lifetime 638979, is senior editor for EAA digital and print content and publications, co-author of two books, and a lifelong pilot and aviation geek. Find him on Facebook, Twitter, and Instagram at halbryan or e-mail him at *hbryan@eaa.org*.

Most AirCam pilots today aren't flying research missions over the types of harsh and impassable terrain for which the airplane was built. They're out flying for the purest love of it, enjoying the scenery, dropping in on a grass strip or a lake somewhere simply because they can.

The new cockpit enclosure still offers an amazing view, even from the rear seat.

PHOTOGRAPHY BY **ERIN BRUEGGEN**

WELCOME
OSHKOSH 2010 AirVenture
Salute To Veterans
1993 was a busy year on the flightline
EAA INTERNATIONAL 1965 FLY-IN
CHAMPION
We flew on the "Tin Goose" -1968
Best. Selfie. EVER!!!
Rockford 1964-Dad flies in for the first time!
INTER NATIONAL 1964 FLY-IN
EAA
2014 EAA
2016 EAA THE SPIRIT OF AVIATION

EAA HOMEBUILDERS
INTERNAT'L EXPERIMENTAL AIRCRAFT ASSOC. FLY-IN CONVENTION
A Family Tradition Since 1953
EAA AirVenture Oshkosh has always been the place where the EAA family gathers to celebrate and create lasting memories and traditions. Come home and be a part of the world's largest family reunion.
THANK YOU VETERANS
WELCOME HOME GRANDPA
2004 EAA CHAMPION
2002 EAA CHAMPION
EAA AIRVENTURE OSHKOSH 2017
Kay Marschall
Wow I know someone who will want to celebrate a birthday in Oshkosh!
Randi Siegfried
Yep! All of us will be there...
John Shurts
Woo hoooo! I'll be there - 29th year in a row!
Terry Hutchens
That's us (more or less) waiting And waiting.
Write a comment...
2007
World's Greatest Aviation Celebration® | July 24-31 | EAA.org/Tradition

Turning NO

EMBRY-RIDDLE'S EAGLE FLIGHT RESEARCH CENTER

BY BETH E. STANTON

EMBRY-RIDDLE AERONAUTICAL UNIVERSITY'S EAGLE Flight Research Center (EFRC) at the Daytona Beach, Florida, campus is a world leader in the study of alternative aircraft propulsion. The EFRC studies four areas of manned and unmanned systems: propulsion, unmanned aircraft systems (UAS), flight controls, and certification. It currently has almost two dozen projects in the works spanning electric, hybrid electric, UAS, unleaded aviation fuels, and simplified and autonomous vehicle operation.

PHOTOGRAPHY BY **DAVID MASSEY**

Into YES

Dr. Richard "Pat" Anderson stands with the electric engine on the Daytona Beach Campus, at Eagle Flight Research Center.

Pat with his wife Carolina and their two daughters, Sidney and Caroline.

Pat Anderson, EAA 563256, is a professor of aerospace engineering and director of the EFRC. His scope of experience in almost every facet of aviation gives him uncommon insight. Pat is a CFI in single- and multi-engine airplanes and gliders, an ATP, and an A&P mechanic with inspection authorization (A&P/IA).

"A lot of what I do is driven by the people around me and the things I would personally like to do with airplanes," Pat said. He sees two facets to explore in general aviation: transport and sport. "I want to make air transportation accessible and safe. There's also the sport aspect because I fly fun airplanes." Pat is an active EAA member and recreational pilot. He and his wife, Carolina, fly a Cessna 180, Pitts S-1T, Husky, and Schweizer 2-33A glider.

PAGING DR. ANDERSON

Pat was the first in his family to aim for a college education. He had a talent for science, but a hearing disability led to less than stellar grades in high school. Through a Civil Air Patrol scholarship, he attained a private pilot certificate. He applied to Penn State University for aerospace engineering and was accepted into the Abington campus for the first year. College suited his learning style, and he soon excelled.

Thinking he couldn't afford to fly traditional planes, Pat connected with the glider community near State College, Pennsylvania, and came to love flying up and down the ridges in gliders. Around this time, Karl Striedieck and Thomas Knauff were setting sailplane records on Bald Eagle Mountain. Pat lived at Eagle Field as Karl's second lieutenant, flying the "best airplanes in the world" for five years while he was in school.

Pat completed his undergraduate degree and went on to study for a master's degree in aerospace engineering. During summers in grad school, he managed Harris Hill Soaring Center in Elmira, New York, and got to know Steve Sliwa. When Steve became president of Embry-Riddle Aeronautical University, Pat applied for a job. Steve was enacting a new policy requiring doctorate degrees for all Embry-Riddle professors.

"You fly really good," Steve told Pat. "So we'll let you onto the flightline, and if you do well, I'll help you." While working full time as a line instructor pilot and teaching engineering courses at Embry-Riddle, Pat earned a doctorate degree in mechanical, materials, and aerospace engineering from the University of Central Florida.

Pat has been at Embry-Riddle now for 20 years and was the first person at the university to be granted tenure in the College of Aviation and College of Engineering.

PHOTOGRAPHY COURTESY OF PAT ANDERSON

GRASSROOTS RESEARCH

"Nobody in the administration said, 'Hey, go do this.' We had a whole bunch of airplanes, pilots, and engineers. Why don't we do novel things with airplanes? We just made it happen," Pat said.

Embry-Riddle started in 1925 in Cincinnati, Ohio, as a pilot and mechanic school, moving to Miami, Florida, in 1939. In 1965, the campus moved to Daytona Beach and added an aerospace engineering department. The university has always been known as a teaching institution, but also wanted a research division.

The fledgling Eagle Flight Research Center started in 1998 when Pat, Pete Pierpont, and Thierry Saint Loup put an SMA 305 diesel engine on a Cessna 182. "There was no roadmap," Pat said. "Here was step one; we can make this. We looked around and said we can make this next step." The next project was a modified Stemme S10: the Eco-Eagle, a hybrid electric piston aircraft designed and flown for the 2011 NASA Green Flight Challenge.

The EFRC gained traction and began growing. "We've been able to get the resources we need to do these interesting projects by proving to our administration that we can do them and that they are of interest to the world," Pat said.

STUDENT-DRIVEN RESEARCH

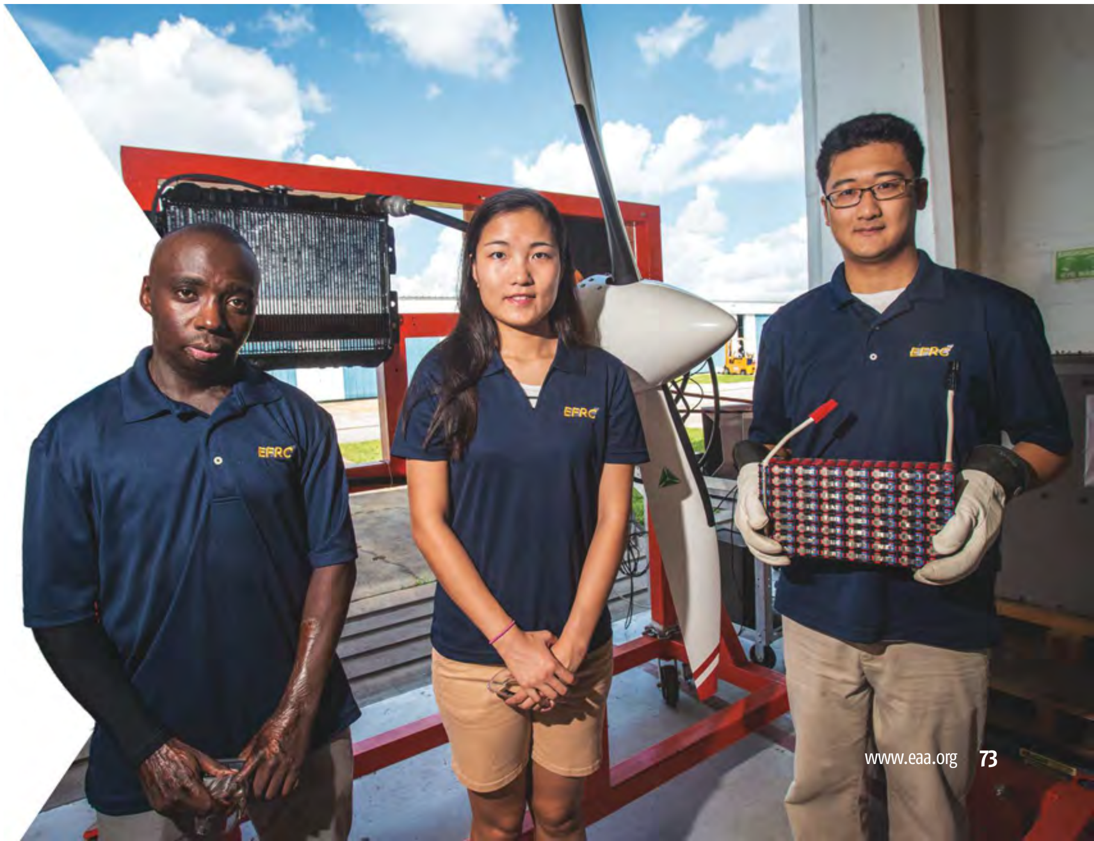
Embry-Riddle has the largest aerospace program in the United States. "We may not be Stanford or MIT, but when people really love both engineering and aviation, they end up here," Pat said. "We have some of the best of the best here." Developing diverse engineering projects at the EFRC is the domain of students of all levels. Undergraduate students are given free rein to choose projects to work on. "They start coalescing around the project that excites them," Pat said. "You have these bright, highly motivated students who love to be here."

Pat claimed he's "not as bright as the students" at EFRC. He keeps his finger on the pulse of the students by continuing to teach and not just conduct research. Pat was honored as the 2012 Florida State University Professor of the Year by the Carnegie Foundation for the Advancement of Teaching. The students and faculty at the EFRC are a close-knit community with a camaraderie that extends beyond projects. Friendships are forged in the lab. Work and play mix with parties and barbecues celebrating birthdays and graduations.

Dozens of undergraduates are managed by about 20 master's students who are overseen by professors with doctorates, an A&P/IA, and Pat for technical oversight and safety. Embry-Riddle is one of the last universities to fly experimental student-built airplanes. Risk is mitigated by a stringent safety culture. "The EFRC gives students one of the few opportunities to work with real aircraft hands-on," said Lenny Gartenberg, a master's student who has been working on various EFRC projects for three years. "The aircraft we use here are full size and manned instead of the typical small UAVs." Students are forced to blaze their own trail. "We often have no external resources or references to refer to when doing our work to help us out," Lenny said. "In my work with hybrid, there are no proven hybrid concepts for aircraft that are out flying today. It's a challenge to not only create our tool, but validate our results without any real test data publicly available."

The EFRC motto is: *How to make no into yes*. "I like the fact that my work is not only new but can actually make a sizable difference in the industry," Lenny said. "My hope is that our work here can help shape the aviation industry for decades to come in alternative propulsion."

Below: *From Left: Milton Marwa, Project Lead, "Victoria" Jingsi Li, Battery Management Systems Developer, and "Tony" Tianyuan Zhao, Project Lead for Electric Aircraft HK36, members of the Eco Eagle project at Embry-Riddle Aeronautical University's Eagle Flight Research Center.*



PHOTOGRAPHY BY **DAVID MASSEY**

PROJECTS

"What's exciting about the Eagle Flight Research Center under Pat's leadership and vision is that they are doing extraordinary things. It's not just electric propulsion; it's an all-encompassing pathway towards on-demand mobility and personal air vehicles," said Erik Lindbergh, CEO of Powering Imagination, who is closely involved with Embry-Riddle's electric and hybrid aircraft efforts.

- ***e-Spirit of St. Louis***
  The *e-Spirit of St. Louis* was launched when Erik, Charles Lindbergh's grandson, approached Pat about a partnership with Powering Imagination to build a clean and quiet electric airplane. The project includes funding from the National Park Service as well as crowdsourcing. The modified Diamond HK36 all-electric aircraft demonstrator is an ex-Skunk Works plane donated by Lockheed Martin. All the aircraft's electric systems were designed, built, and tested by students. The aircraft will demonstrate the fundamental design aspects of electrified propulsion for aircraft including noise reduction, fossil fuel reductions, carbon dioxide emissions reduction, and reductions in direct operating costs. The goal is to not only develop and fly the electric airplane but also obtain a supplemental type certificate from the FAA, making it one of the first fully electric aircraft certified in the United States. The aircraft will be ready to fly by summer 2017. See a video of the *e-Spirit* in action at *www.EAA.org/extras*.

- **Hybrid Electric Aircraft Consortium**
  The Hybrid Electric Aircraft Consortium is studying the feasibility of a nine-passenger hybrid electric turboprop. The consortium was founded by Embry-Riddle and includes Airbus, GE, Rolls-Royce, Pratt & Whitney, Textron, Hartzell, Cape Air, and the Argonne National Lab (Energy Systems Division). Since all-electric propulsion will be limited to lighter, slower aircraft for the near future, a hybrid turboprop airplane may have commercial applications. The consortium study is pooling industry resources for a pre-competitive look at the viability and the maturity of this technology. A prototype hybrid motor is slated for 2018.

- **Heurobotics Mk. II**
  The Heurobotics Mk. II VTOL unmanned aircraft system (UAS) is a hybrid electric mixed twin-engine helicopter and fixed-wing vehicle that takes off as a helicopter and transitions to fixed-wing flight. It has the advantages of a fixed-wing aircraft but lands in the footprint of a helicopter. It developed from previous work on three other projects: electrified propulsion, hybrid turbine, and controls. When researchers began driving the algorithms in all three of those projects, they realized they could have a vehicle with characteristics similar to a V-22 Osprey, but it would be mechanically simple with a computer making it controllable, stable, and autonomous. Heurobotics, an Embry-Riddle spinoff company, is developing the UAS as a commercial product for agriculture and construction. A scaled-up version of the technology may ultimately transfer to manned aircraft.

- **On Demand Mobility/ Simplified Vehicle Operations**
  On Demand Mobility/Simplified Vehicle Operations (ODM/SVO) is a prototype manned personal air vehicle that could replace a car. "If there is a widespread acceptance of self-driving cars, a very different GA may spring up," Pat said. "With simplified vehicle operation, you type on a keyboard where you want to go. There is no stick and rudder." The vehicle will take off as an electric, eight-motor helicopter and by use of tiltwings, transition to forward flight. The aircraft has the footprint of a car that

The Heurobotics Mk.II is flanked by the restored Waco Model 10 Embry-Riddle was founded with and the e-Spirit of St. Louis.

Students check out the glider at the Eagle Sport Avaition Club booth during the annual Activities Fair on the Connolly Quad, Daytona Beach Campus of Embry-Riddle Aeronautical University.

could take off vertically in a driveway and fly to a parking space at work. "I was beside myself when it dawned on me that we literally have everything on the shelf to do this," Pat said. "It's now just a matter of putting together the appropriate collection of things we already know how to do." The team is moving fast to build the prototype, using dozens of grad students to get the project to manned hover flight by summer 2017.

- **Navion In-Flight Simulation/ Fly-By-Wire**
  The EFRC is in partnership with the FAA Small Airplane Directorate and Flight Level Engineering using a Navion variable stability in-flight simulator aircraft as a national asset for Part 23 automation in simplified vehicle operations. It has been updated with a glass panel and full digital fly-by-wire on the left side and traditional controls on the right. The airplane is outfitted with analog and digital computers capable of simulating the handling qualities of multiple types of airplanes. The aircraft will be used to research simplified fly-by-wire for GA airplanes that may allow for operations with limited pilot training. It would be similar to the SVO concept but retrofitted for the existing fleet.

SHARING INNOVATION

"There are still people who envision tube and wing airplanes forever. I don't share that; the younger generation doesn't share that," Pat said.

Pat sees a merger not only of various technologies, but also of various industries that are changing public opinion and awareness of these possibilities that now exist. Cars and airplanes have had the same look for 100 years; they may not in the next 25 years.

"I'm in a little bit of a unique position because I understand the controls aspect, propulsion, aerodynamics, and how to build stuff," Pat said. "I see when things cross thresholds across all these technologies. Some things we couldn't do technologywise a year ago, but in a year it *will* be something we can do. I can look across many different fields and see what is coming of age in each of them. You can see the interaction that is going to occur to make a vehicle that we just couldn't make five years ago or even conceptualize five years ago."

The EFRC occasionally does proprietary work, but in general it is open to the public and welcomes guests. "We've had people from EAA 288 here and certainly invite people to come and see the technology we are developing and foster that because innovation is with the homebuilder EAA folks," Pat said. Anyone is free to visit the campus and check out the battery packs, management software, and motor controller software that allow electric propulsion to work and adapt the technology for their own use.

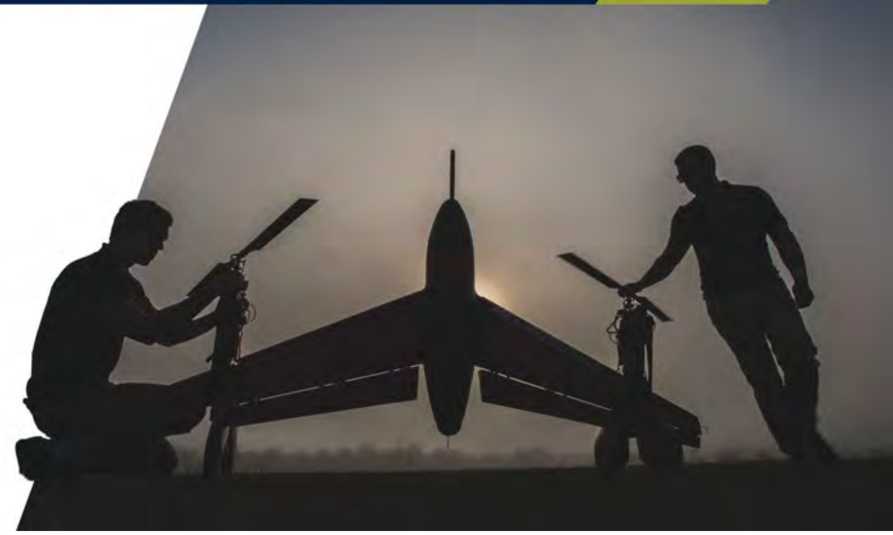
"EAA members have done a lot of the innovation that works its way up into airplanes. You can think of it as levels," Pat said. "Now there is a level below for doing really extreme stuff before you put a human in it. It might be that EAAers use UAVs or complex model airplanes to figure out stuff before they put their own rear end in it."

SPORT

Pat founded the Eagle Sport Aviation Club in 1998 with the acquisition of a Pitts S-2B. It's the world's largest aerobatic aircraft owning club. "A lot of people donated to the Pitts including Tom Cruise, who learned to fly in that plane. We took donations for half, and the university gave us a loan for the remainder," Pat said. An estimated 500 first-time competitors have flown the Pitts in aerobatic competition. The club has branched into three divisions: aerobatic, antique tailwheel, and soaring with the addition of a J-3 Cub, Piper Pawnee, and Schweizer 2-33 glider.

Pat and Carolina met while he was teaching her aerobatics in the Pitts. Carolina came to Embry-Riddle to get a commercial rating and never left. After earning her master's degree, she worked as an instructor and check airman and was the first female doctorate student at Embry-Riddle. "She liked aerobatics, we liked each other, and the rest was history," Pat said. Their two daughters, Sidney Piper, 7, and Caroline Skylar, 2, have been to Oshkosh every year since they were born. When little Caroline sees the family Cessna 180, she cries, "Red airplane, red airplane!" "She just started talking so it's pretty cool," Pat said.

PHOTOGRAPHY BY **ERIN BRUEGGEN, DAVID MASSEY**



BRIGHT FUTURE

"When I graduated, aerodynamics was dead, and now it is alive as can be," Pat said.

Pat considers the big three drivers of innovation to be electric propulsion, controls, and easement of regulations toward consensus standards. "It's really the technology," Pat said. "Electric propulsion and controls are allowing us to design vehicles that don't have to be in the shape of an airplane. They can be any way you want using multiple electrical motors. Modern adaptive controls make the vehicle fly the flight plan you want with these crazy-looking propulsion systems."

MORE EFRC PROJECTS

Avgas Testing:
Performing company tests and/or certification tests on Shell, GAMI, and Swift's unleaded 100 octane fuels.

Aircraft Parameter Identification:
This project is developing rigorous mathematical models of future concept vehicles using flight test data. This will feed the control systems required to control unstable and unconventional future concepts, a key technology in the development of robotic "learn-to-fly" programs.

Stability Proofs for General Aviation Adaptive Control Autopilots:
This is a program that demonstrated that an adaptive "wrapper" can be placed on top of an existing autopilot to allow those autopilots to control any Part 23 aircraft without the need for tedious gain tuning. This research resulted in a rigorous mathematical proof that this confirmation is stable at all times, a key FAA requirement.

Stability Proof for Unstable Plant Autopilots:
This program is extending the above research to nontraditional, futuristic aircraft configurations.

Electronic Mag:
This is investigating the viability and certifiability of an electronic mag on Part 23 aircraft.

Waco Model 10:
Restoration of the original Waco Model 10 the university was founded with in 1926.

> "When I graduated, aerodynamics was dead, and now it is alive as can be."
>
> \- Pat Anderson

Also enabling growth is the movement to American Society for Testing and Materials (ASTM) standards away from the more proscriptive rules of Part 23 certification. "I have a lot of hope for general aviation if we can overcome some of the certification hurdles," Pat said. "All things are in position right now to allow a rapid expansion over the next 10 years, not only for mobility, but for fun and the betterment of the Earth. Aircraft will be more efficient, with less greenhouse gases, less noise, and better point-to-point transportation. I'm very optimistic." *EAA*

Beth E. Stanton, EAA 1076326, is a competition aerobatic pilot and president of Northern California Chapter 38 of the International Aerobatic Club. She can be reached at *bethestanton@gmail.com*.

PHOTOGRAPHY BY **ERIN BRUEGGEN, DAVID MASSEY**

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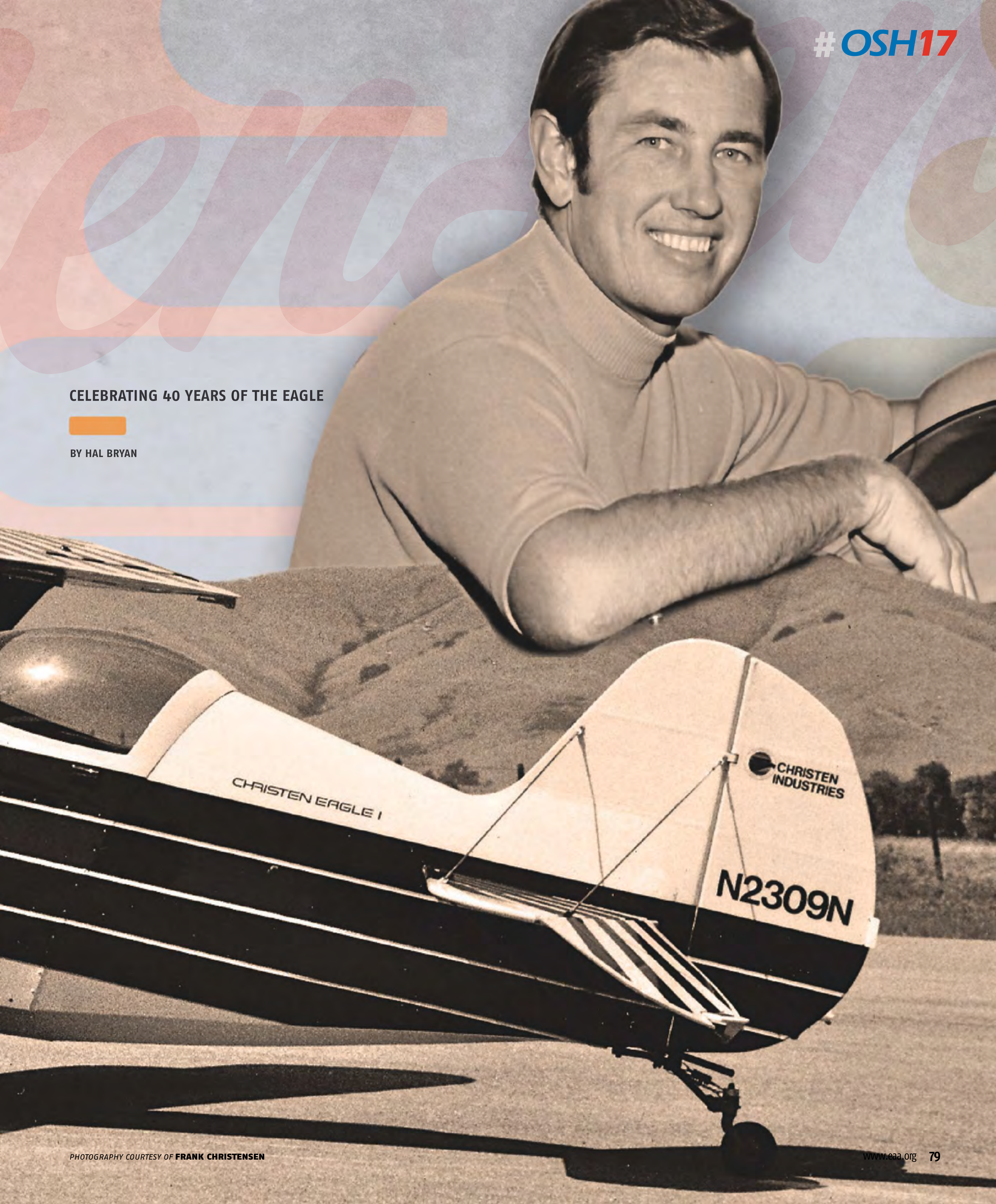


CELEBRATING 40 YEARS OF THE EAGLE

BY HAL BRYAN

PHOTOGRAPHY COURTESY OF **FRANK CHRISTENSEN**

ABOUT 45 YEARS AGO, Frank Christensen, EAA Lifetime 36663 and IAC 90, had an idea while developing the Christen Eagle II.

"Let's make this airplane a kit," he said. "We'll make it so complete and so detailed and support it with such elaborate illustrated documentation that any guy with reasonable mechanical aptitude and some hardware store tools could build his own airplane." To describe an Eagle kit is to describe Frank: innovative, clear, exceptionally well organized, methodical, thoughtful, backed by solid engineering.

When Frank was growing up in Salt Lake City, his father was manufacturing tools for the petroleum industry and did a lot of flying in support of that.

"He encouraged me to learn to fly," Frank said. "He used to tell me that everybody in my day was going to travel by airplane." When he was 16, Frank started training in an Aeronca Champ, but didn't take to it right away.

"I wasn't particularly interested until I found out that the girls in my high school were impressed," he said. "I suddenly became interested." Once he passed his checkride, he built some time in his uncle's 172 before heading off to Stanford, majoring in industrial engineering and economics. While he was there, he was introduced to aerobatics by his gymnastics coach, a pilot who'd flown in World War II. The coach took him up and did a couple of loops and rolls. As Frank tells it, his coach said, "This is more fun than doing somersaults on the ground."

While he was at Stanford, Frank did some work for his father's company and then, as a senior, started a business of his own making tooling for Fairchild Semiconductor. He named the business Tempress, a portmanteau of "temperature" and "pressure," and supported Fairchild as it developed the first integrated circuits. With help from Tempress, Fairchild kicked off the modern computer revolution, and thanks to its choice of materials, the southern part of the San Francisco Bay Area got a new nickname: Silicon Valley.

Frank downplays his role, dismissing it as a right place, right time sort of thing. But if you're reading this on an iPad or your laptop, you can thank the integrated circuit, and, at least indirectly, you can thank Frank. For that matter, since this magazine was composed, edited, designed, laid out on, and then printed by computers, you can thank him even if you're reading it on paper.

With the growth of electronics fueled in large part by the Cold War, business boomed. In 10 years, Frank built Tempress up to a company of 400 employers with suppliers and customers all over the world.

"We were in a unique position because nobody else had gotten into it way back in the beginning," he said. As Tempress grew, Frank bought a Cessna 320 to visit customers and suppliers. By 1967, he'd grown frustrated that the airplane couldn't get above a lot of weather so he did what any sensible businessman would have done: he bought a P-51 Mustang.

"I saw an advertisement in *Flying* magazine for P-51s converted for corporate use," he said. "They would buy up a surplus P-51 … and turn it into a two-place high-speed transport … so we sold our twin Cessna and bought one."

As part of his checkout in the Mustang, Frank was reintroduced to aerobatics. This led to a fateful introduction to Curtis Pitts and Frank's purchase of a Pitts S-1S soon thereafter. Frank shared the airplane with a friend, and they started teaching themselves more advanced maneuvers.

SPECS

Aircraft Make & Model: Christen Eagle II
Certification: Experimental amateur-built
Length: 17 feet, 9 inches
Wingspan: 19 feet, 11 inches
Height: 6 feet, 6 inches
Maximum gross weight: 1,578 pounds
Empty weight: 1,025 pounds
Fuel capacity: 25 gallons (24 usable)
Seats: 2
Powerplant Make & Model: Lycoming AEIO-360-AID
Horsepower: 200
Propeller: Hartzell HC-C2YK4/666A-2 constant speed
Cruise speed/fuel consumption: 165 mph/8.5 gph (estimated)
V_{NE}: 184 mph
V_{SO}: 58 mph

FRANK'S P-51

Whatever happened to Frank's Mustang, the fighter-turned-corporate-transport by Cavalier Aircraft? Well, Frank eventually sold it to a man by the name of Jerry Brassfield who, along with co-owner Robert Love, raced the airplane until 1977 when it was repainted as a warbird and donated to EAA. It was christened *Paul I* and flew as Paul's signature airplane until it was retired to the museum in 2002.

The birth of the Eagles: Frank's fateful meeting with Gene Soucy, Charlie Hillard, and Tom Poberezny in Tom's signature Beetle, Red 3.

"Then we learned that there was such a thing as aerobatic competition so we decided we would go try our hand at it," he said. Frank flew his first competition in 1969 then competed again in 1970 and 1971. During that time, he got to know three more guys who would change his life: Charlie Hillard, Gene Soucy, and Tom Poberezny.

"I didn't do very well in the 1971 contest, but I got invited to manage the team ... so I went to France with the team in 1972," he said. That year, Charlie was the individual world champion, and he, Tom, and Gene won the team world championship. This marked the first time since the competition's founding in 1960 that the United States had won.

Before he went to France, Frank realized that he was more interested in airplanes than he was in making tools and sold Tempress to a conglomerate. After he came back from Paris, he realized that he was more interested in designing and manufacturing airplanes than he was in competitions. He'd started building a lot of "gadgetry" for Pitts — inverted oil systems, manual fuel pumps, etc. — under the auspices of a new company named Christen Industries Inc., based at his home in Hollister, California. But he thought there would be a better market for an airplane than there would be for parts.

To describe an Eagle kit is to describe Frank: innovative, clear, exceptionally well organized, methodical, thoughtful, backed by solid engineering.

This image of Christen draftsman Don Lee with the entire contents of an Eagle kit was an iconic piece of advertising for the company.

Frank approached Pitts about buying his business, but they couldn't come to terms, so he decided to build a design of his own. About that time his friend Herb Andersen, a former engineer at Pitts who'd started his career at CallAir in Afton, Wyoming, was leaving Wyoming, so Frank invited him to come lend a hand on his new project.

"So he came to California," Frank said. "We put together a team of people and started to design our own aerobatic airplane." The airplane would use the Pitts as a starting point, but Frank wanted to improve it any way he could. In addition to Herb, he recruited Pete Nettinger to do the mechanical work and Ivan Clede, a technical illustrator who would work on the documentation and a lot of style work for the airplane as well.

The team set to work designing an airplane that would be roomier and more comfortable than the Pitts with improved aerobatic performance, better visibility — in the air, if not on the ground — and better ground handling, thanks in part to spring-steel gear, among other improvements. The airplane was built using traditional methods, including a welded steel-tube fuselage and wood wings that are fabric covered, powered by a 200-hp Lycoming IO-360.

Frank and his team had one other plan for the prototype as well: certification.

"We did a complete FAR Part 23 certification package," he said. "We were going to set up a production line and actually produce it as a finished airplane." Something about this didn't feel right, though: They would be competing directly with the Pitts. Then one of Frank's team suggested that they sell it as a homebuilt, and Frank was intrigued. He'd been a tinkerer since he was a kid and had always loved building things, especially radios and other electronics from a company called Heathkit.

Could he produce a kit that didn't require the builder to be an engineer or an A&P?

"The thing I remembered about [Heathkit] is that you didn't have to know anything about radio ... in order to build a radio," he said. Could he do that with an airplane? Could he produce a kit that didn't require the builder to be an engineer or an A&P?

"Let's do it like Heathkit," he said. "We'll break it down into component parts, like the ailerons and then the wings and then the fuselage ... and on and on and on." With that new direction in mind, they abandoned the production line and FAA certification and started dividing the airplane into sections. Eventually, they came up with 26 individual kits, starting with the ailerons and ending with the instructions for your first aerobatic flight. Individual parts were meticulously vacuum-packaged and would contain everything the builder would need to complete the kit before moving on to the next one. And when Frank said "everything," he meant it.

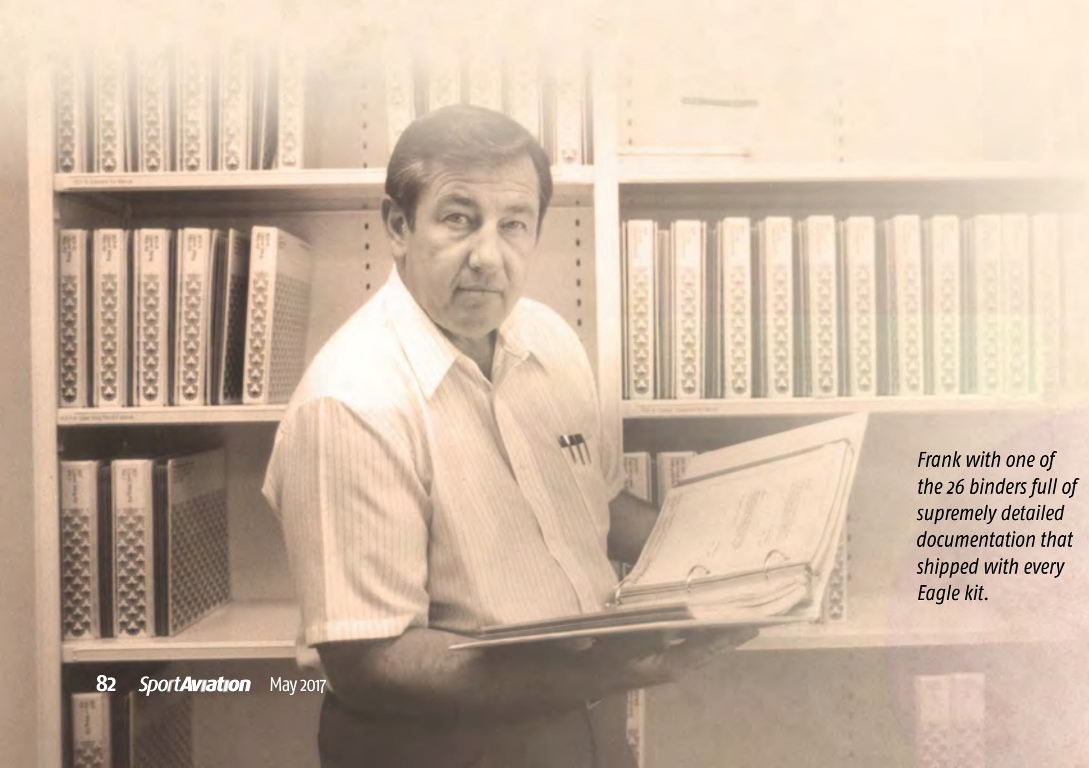
"I have the unfortunate reputation for being a detailist," he said, "I said, 'If a guy gets this kit, he's going to have to open it. Give him a razor blade to make it easy.' So there was a little razor blade with a label on top of it that said 'Use this to open the vacuum packaging.'"

Each of those kits would also be accompanied by a three-ring binder containing what are arguably the most detailed instructions ever included in an airplane kit, instructions that would ultimately take up four feet of shelf space. They were updated constantly thanks to a remarkably sophisticated computer system for the time, with paper revisions sent out to every registered buyer from the time they purchased the kit until they told the company that the airplane was finished. For more, see "The Christensen Method" in the March 1982 issue of *Sport Aviation*.

EAGLE 2FC — MUSEUM

The original Christen Eagle II prototype, N2FC, stands on its tail in a striking vertical display in the EAA Aviation Museum. The proud centerpiece of the museum's Air Racing and Aerobatics gallery, the first Eagle hangs above an exhibit that details its history and, in particular, the impact the airplane had on the homebuilt kit industry. The exhibit shows sample parts from an Eagle kit along with a collection of bound instruction manuals like those that have made the airplane an attainable build project for the last 40 years.

Frank Christensen donated the airplane to EAA in 2011, and the exhibit was officially unveiled in December of 2012, when Frank was the featured speaker at EAA's annual Wright Brothers Memorial Banquet.



Frank with one of the 26 binders full of supremely detailed documentation that shipped with every Eagle kit.

Eagle in Christen booth at Oshkosh 1977.

As the kits were being prepared, it was time to start marketing the new airplane, but there was a problem; it didn't have a name. That's when Frank reached out to the design firm of Steinhilber and Deutsch. Frank had worked with Budd Steinhilber, a remarkable designer whose portfolio includes everything from the 1948 Tucker Torpedo sedan to Pabst beer and Atari video games, back in his days at Tempress. Steinhilber and his partner, Barry Deutsch, immediately homed in on the idea of naming the airplane after a bird and came back to Frank with their first suggestion. Had he gone with it, today we'd be celebrating the triumphant 40th anniversary of the Christen Ostrich. After the Ostrich didn't fly, so to speak, the designers came back with something more appropriate: Eagle. Frank's initial concern was that it was too common, but the designers said that was a strength.

"It's so common that it's uncommon," Frank remembered them saying, "and it makes the statement you want to make that this is something special." The airplane would officially be known as the Christen Eagle II, the II not indicating a model number but reinforcing the fact that this is a two-seat airplane. From there the firm, with Deutsch in the lead, designed the now iconic multicolored stylized feather paint scheme. With the airplane named and its look defined, it was time to start finding customers, so Frank took out a series of magazine ads that left everything to the imagination. The ads consisted of a striking close-up photo of a bald eagle, and the only copy was "The Eagles Are Coming!" These ads ran every month in 1977 until that year's convention in Oshkosh when the airplane was officially unveiled.

Christen advertisments

"We introduced it at Oshkosh with a big booth with the actual airplane there and sample kits … it was really a big thing that year," Frank said. In the convention recap in *Sport Aviation* that year, Jack Cox described the Christen display as "absolutely opulent" and the company itself as "absolutely first class."

"The only problem was the FAA didn't like it," Frank said. The rumor was that the airplane wouldn't qualify as amateur-built because the kit was too complete. Once back from Oshkosh, Frank flew to Los Angeles to meet with the FAA face to face. He brought photos and a sample kit, and explained that, in spite of the ease of construction, the airplane still demanded as many as 1,800 man-hours to build; surely that would satisfy the 51 percent rule?

No, it wouldn't. Frank wasn't given any real answer beyond that this was a subjective decision, and it was final. Frank reached out to Paul Poberezny who connected him with an FAA contact in Washington, D.C., who told the guys in Los Angeles to give Frank a better answer.

While that answer still wasn't "yes," it did offer some clarity. Basically, the FAA's definition split the airplane's components into two categories: *procured* for things you'd buy like wheels, brakes, engine, and prop, and *fabricated* for things you'd build, like the wings, fuselage, etc. Of the latter, the FAA decreed that 51 percent of those parts had to be fabricated from raw materials versus simply assembled by the builder.

Frank went back to his team, and they did an analysis of the fabricated components and determined that, yes, as their kits stood only about 22 percent of them met the FAA's definition. Then they looked at the wing ribs and realized that each one was made up of about 300 individual parts. So, they created new wing rib kits so that builders could cut the wood for every gusset and tab, and presented the updated plan to the FAA. As the kit now met the letter of the law and then some, the FAA approved and Christen was free to start selling Eagles.

EAGLE'S *40*TH AT AIRVENTURE OSHKOSH 2017

The Christen Eagle II was introduced to the aviation world at EAA Oshkosh 1977. At AirVenture 2017, we will celebrate the 40th anniversary of this award-winning aerobatic biplane. The International Aerobatic Club (IAC) will highlight the history and the development of the Eagle in its pavilion on the AirVenture grounds. Six exhibit panels will tell the story of this iconic aerobatic and sport aircraft and the pilots who flew it. A forum on the Eagle will be held at the IAC pavilion on Tuesday, July 25, from 8:30 to 9:45 a.m. Speakers will be Mark Ciagla and Lynn Ojala, owners and pilots of Eagle aircraft. Both will bring their Eagles to AirVenture this year with Lynn's being displayed at the Aviat exhibit.

The IAC is also proud to announce that Frank Christensen will attend AirVenture and be onsite at the end of the week and a guest at IAC's gathering of members in the Nature Center on Friday, July 28, at 6:30 p.m.

PHOTOGRAPHY COURTESY OF **FRANK CHRISTENSEN, EAA ARCHIVES**

Christensen with Herb Andersen at the Afton factory.

After the hype building up to the launch, Christen continued its astute marketing campaign, creating a print ad with draftsman Don Lee in a white lab coat standing behind the complete contents of a single Eagle kit, illustrating perfectly that everything truly was included. In addition, Frank reached out to his old friends Gene, Charlie, and Tom, and got them to form the Eagles Aerobatic Team, a popular air show act that showcased the airplane for more than 15 years (see sidebar).

It seems unlikely, but this high-end, high-performance biplane democratized homebuilding in a big way, setting the standard for aircraft kits to come.

The kit wasn't cheap, nearly $42,000 by 1982 (more than $100,000 today), though that figure included everything but paint. And nobody would consider the Eagle to be a beginner's airplane — it's a high-performance taildragger built for competition aerobatics. You needed a fair amount of money to buy it and a reasonable amount of skill to fly it, but, as Frank said, you don't need much to build it. It seems unlikely, but this high-end, high-performance biplane democratized homebuilding in a big way, setting the standard for aircraft kits to come.

Over the years, more than 1,000 Eagle kits were sold to customers all over the world. More than 800 of the buyers built their way at least as far as the fuselage kit, generally considered to be the "if they go that far, they're going to finish the airplane" point. It's estimated that several hundred are flying to this day. And Frank finally did buy Pitts from Curtis' successor, Doyle Child, in 1983, and consolidated both operations in the Pitts factory in Wyoming. The company sold Eagle kits and Pitts Specials, and introduced a new airplane, the Husky that was meant to be to the Super Cub what the Eagle was to the Pitts.

Frank grew frustrated by a series of baseless and frivolous product liability lawsuits, something that comes as no surprise to anyone familiar with the state of general aviation in the United States in the 1980s, and sold the company to Aviat in 1991, which has changed hands but still produces the Husky, Pitts, and the Eagle. Since that time, Frank has enjoyed a well-deserved retirement, summering in Wyoming and wintering in Utah, dabbling in architecture and furniture design, and occasionally flying with his grandson who is a CFI in Texas. He sold his last airplane, a Cessna 441, about 10 years ago when he realized he was only flying it back and forth to his mechanic for its annual.

WANT MORE AEROBATICS?

Are you bored with "straight-and-level"? Do you think you might be happier upside down? If so, you'll want to check out the International Aerobatic Club, the EAA division dedicated to promoting and enhancing the safety and enjoyment of aerobatics. Whether you fly aerobatics for fun or in competition, or if you want to, or even if you simply like to watch, we invite you to consider adding International Aerobatic Club to your EAA membership. For more information, visit *www.EAA.org/IAC.*

BLACK EAGLE AND THE EAGLES AEROBATIC TEAM

Just as Frank was getting started with the Eagle, his friend Gene Soucy asked him if he'd build him a custom single-seat version with a 260-hp engine. Frank set to work and built the first Eagle I. The usual rainbow plumage was done all in black to give it a more serious look, and, two weeks after taking delivery, Gene flew the *Black Eagle* to second place in the U.S. National Aerobatic Championships.

Gene's appreciation for the single-seater gave Frank another idea. He approached Gene, Charlie Hillard, and Tom Poberezny, by that time well established as the Red Devils aerobatic team, to trade in their Pitts S-1s for a trio of Eagles. They jumped at the idea, and the Eagles Aerobatic Team was born, with airplanes, posters, brochures, flight suits, and even luggage provided by Christen Inc., in exchange for the powerful promotion provided by the popular air show act for years. The deal was based on nothing more than a handshake, and the Eagles flew with Christen sponsorship and then, later, Avemco from 1979 until their final retirement in 1995.

The *Black Eagle* was eventually sold to a 727 pilot in Texas who maintains it in pristine condition and still flies it to this day. The Eagles' airplanes are displayed along with their forerunners, the Red Devils' Pitts S-1 biplanes, suspended in the EAA Aviation Museum's lobby.

As we look back on the Eagle and look forward to celebrating Frank and his success at AirVenture Oshkosh 2017 you have to wonder how that feels for him. After all, his contributions to the E-AB movement and the world of sport aerobatics are significant enough that no less than four Eagles, including the prototype, are displayed proudly in our museum. It's not surprising that, when asked about this, Frank's response is as concise as it is sincere — and as modest.

"It feels really good to know that the airplane was a success and that it apparently had enough of an effect on people's lives that they still remember it," Frank said. *EAA*

Hal Bryan, EAA Lifetime 638979, is senior editor for EAA digital and print content and publications, co-author of two books, and a lifelong pilot and aviation geek. Find him on Facebook, Twitter, and Instagram at *halbryan* or e-mail him at *hbryan@eaa.org*.

PHOTOGRAPHY COURTESY OF **FRANK CHRISTENSEN, EAA ARCHIVES**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SONEX B

BIGGER AND BETTER

BY MEGAN ESAU

THE B-MODEL IS SONEX'S ANSWER

to all the feedback builders have given about its flagship airplane over the years: increased cockpit space, the ability to hold more fuel, a larger instrument panel, and more. The best part is, all of these things have been accomplished without any reduction in performance.

Announced one year ago at the SUN 'n FUN International Fly-In & Expo at Lakeland, Florida, one thing immediately stood out about this update to the Sonex Aircraft portfolio, known for small, fast, and sporty planes: It's red. Aside from breaking up the sea of signature yellow at Sonex's facilities, this new color helps mark a fresh start in the company's line of aircraft designs. Still, even though the color has changed, the thinking behind the airplane hasn't.

"The B-Model represents the current philosophy, and it reinforces the original philosophy behind our airplanes, and that's that they're simple aluminum airplanes," said Sonex founder and CEO John Monnett, EAA Lifetime 15941. "They're basically a box with a lifting body that's created by a smooth canopy and cowling transition. That contributes tremendously to its performance at both low-speed and high-speed operations."

Perhaps the only thing as important to John as an airplane that flies well is an airplane that flies safely. The Sonex is built to match standard-category characteristics as far as strength and performance, so pilots and aircraft owners get the same safety margins with this airplane as they would with a standard category airplane.

PHOTOGRAPHY BY **ERIN BRUEGGEN**

BEGINNINGS

From the beginning, Sonex has intentionally designed its aircraft to be small. In fact, the company began forming in 1997 to 1998 to meet the need for small airplanes that would fit in the Italian microlight category. To fit the bill, aircraft had to meet a 1,000-pound gross weight limitation, and a maximum stall speed of 40 mph.

"I was commissioned to design the airplane, and my design partner, Pete Buck, and I came up with a clean sheet of paper for an airplane that could be productionized and built with unskilled labor and delivered to customers that might be in, for instance, Italy, who would be flying under this microlight rule," John said. "Turns out that this microlight category or rule was the genesis for what we now call sport pilot, and therefore our airplane was what we call a thoroughbred sport pilot airplane."

When the sport pilot certificate and light-sport aircraft specifications were introduced, they expanded on the framework set by the Italian microlight category, allowing a gross weight of up to 1,320 pounds. John and Pete immediately recognized this as an opportunity for success in the United States' experimental community.

AFTER NEARLY 20 YEARS OF SUCCESS SINCE THE COMPANY'S FOUNDING, JOHN DECIDED TO REVISIT HIS ORIGINAL DESIGN AND INCORPORATE SOME OF THE WISH-LIST ITEMS AND CHANGES CUSTOMERS HAVE MADE ON THEIR PERSONAL BUILDS.

"We had airplanes that were designed to perform adequately well at 80 hp and were all metal, easy to build, and could be constructed by unskilled labor with a minimum of tools," John said. "We knew that that had a lot of potential in our homebuilt category of airplanes and that it would make an excellent kit airplane, or scratchbuilt airplane for that matter, because the plans that were drawn for the airplane were for production and therefore they defined every part that had to be made for the airplane."

The level of detail included in the original Sonex plans meant that builders could potentially build every part from scratch if they so desired. With all the necessary materials ready-made, the pair began marketing plans for the original Sonex and the business began growing to meet the success it recognizes today.

The Sonex line of aircraft now consists not just of the heritage model, but has expanded to include the Y-tail Waiex, single-place Onex, Xenos motorglider, and the SubSonex jet airplane.

After nearly 20 years of success since the company's founding, John decided to revisit his original design and incorporate some of the wish-list items and changes customers have made on their personal builds.

"Just about a year and a half ago, we started talking about how we can improve the model, just as you would improve a new automobile from the last year's model," John said. "In that, we found that making a lot of improvements in the way that it's productionized, the cockpit layout, and some of the other things like computer-generated cowling plugs, made all-over improvement."

BACK TO THE DRAWING BOARD

One of the most significant changes to the Sonex design that comes with the introduction of the B-Model is the expanded cockpit size. Nearly all of the angles in the forward fuselage have changed, and there are very few common parts shared with the original design. With a new width of 40 inches, the cockpit provides the same amount of space as a Cessna 172, an aircraft that for all its advantages is not known for being small and speedy.

SONEX-B SPECIFICATIONS

LENGTH:	18 feet, 1 inch
WINGSPAN:	22 feet
WING AREA:	98 square feet
COCKPIT WIDTH:	40 inches
EMPTY WEIGHT:	620 pounds
FUEL CAPACITY:	20 gallons
CRUISE SPEED:	130–135 mph
STALL SPEED (FULL FLAPS):	40 mph
STALL SPEED (CLEAN):	46 mph
MANEUVERING SPEED:	125 mph
NEVER EXCEED SPEED (V_{NE}):	197 mph
RANGE:	687 miles
COST OF COMPLETE AIRFRAME KIT:	$23,997

For a full list of specs, visit *www.EAA.org/extras*.

Opening up this space has had more outcomes than just comfort. A CFI for the company's T-Flight Transition Training Program noted that with the original model, many pilots transitioning to the Sonex experienced trouble straightening out their landings due to the taper of the fuselage. When landing, people would subconsciously use their peripheral vision to line up the edge of the runway with the lines of the cockpit. This isn't such a problem in most airplanes, because cockpits are traditionally designed with parallel walls, but in the original Sonex many people would land the airplane cocked off to the left. Having these lines straightened out in the new cockpit should take away that optical illusion.

A larger cockpit also means a larger instrument panel, an obvious benefit of the B-Model's design given the general aviation community's general shift toward large, glass-panel displays and dual screens. The choice was also made to install the panel vertically, as opposed to the original design in which the panel is tilted slightly away from the pilot. Not only does this give more room behind the panel for avionics, it also takes away some of the glare issues that were associated with the angled panel.

Sonex was careful not to go overboard with all of these expansions, though.

"We didn't go hog wild with a 42-inch or 43-inch cockpit, because of power-loading considerations," said Sonex General Manager Mark Schaible, EAA 453310. "Our mission is always to leverage smaller engines to get really good performance."

Unlike most kit manufacturers, Sonex produces more than just the airframe — it produces its own line of engines as well: the highly regarded AeroVee.

"I've spent the better part of my aviation career developing engines like the AeroVee engine, and that's what our designs are based around," John said. "We're a unique company in that not only do we produce airframes, but engines for those airframes. That's just a little part — there's not very many companies that do that, and that's our prime focus."

John's expertise in the world of powerplants has had a positive impact on all of the company's aircraft designs, no matter which engine the customer ultimately selects. And speaking of engines, the B-Model offers an expanded list of engine options, adding Rotax and ULPower engines to the traditional Jabiru and AeroVee lineup.

"It gives a little bit more choice out there, especially for our European customers and South American customers that really like the Rotax," Mark said.

Perhaps the greatest draw to the B-Model, one of those instances where more is more, is that the new design can carry four more gallons of fuel than the original, which means more flying time — nearly an hour of it.

Some of these changes incorporated into the B-Model's design came at a cost in weight, though, so Sonex compensated by lightening other areas of the aircraft to ensure there was no real reduction in performance.

Many of the kit's parts, including the base of the stick and the pushrods that extend into the wing, have been changed from steel to aluminum. Further, where once builders would make a number of parts to join pieces of the fuselage, the structure is now a one-piece machine. The resulting design weighs about as much as a comparably equipped A-Model. Though the changes may not be substantial on their own, they add up to a greater whole.

"You get the same speeds that we have published for the regular Sonex," Mark said.

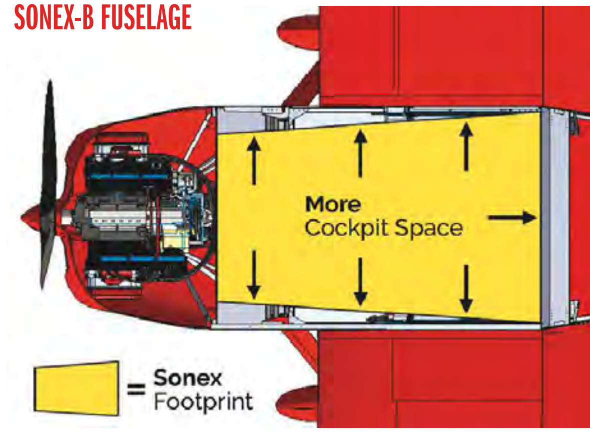
Thanks to the company's T-Flight training program, transitioning into a Sonex is straightforward for just about any pilot, no matter what he or she has been flying previously. For pilots who already have time in a Sonex, transitioning to a B-model is a nonevent.

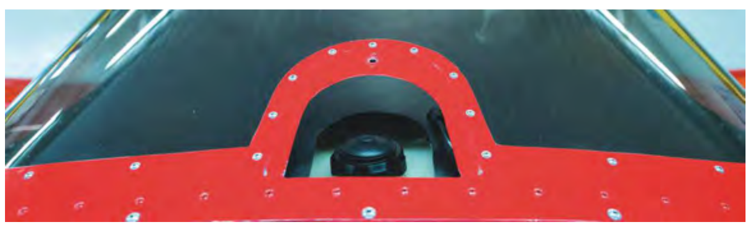
"There's no major changes in controls or anything compared to what we already have in the B-Model," Mark said. "People are coming back that tried the airplane on years ago and ruled it out for comfort reasons and tried the B-Model on and are really liking the change."

Other updates include electric flaps, a Y-stick option, and a windshield skirt, which many Sonex owners had already incorporated into their personal builds to help round off the lines of the airplane.

PHOTOGRAPHY BY **ERIN BRUEGGEN**

SONEX-B FUSELAGE





SONEX-B FUEL CELL

BUILDING THE B

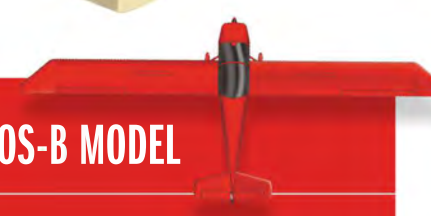
The first B-Model kits shipped in July 2016, and Sonex reported that a number of builders who bought quick-build or conversion kits are getting close to finishing. Going forward, the B-Model will be the only kit offering for the Sonex design. However, anyone who endeavors to build a Sonex from scratch will receive plans for the original design, as those are the only plans that have enough detail.

Customers who have already started building have options, too. Sonex has put together a conversion kit allowing builders who are in the right spot in construction to convert their airplane to a B-Model with little waste. The cost of the conversion kit is $10,000, and the number of people who have purchased it speaks well for how the B-Model increases in space and fuel load were received by the Sonex building community.

"I THINK AT THE END OF THE DAY WE ENDED UP WITH A MUCH BETTER-LOOKING AIRPLANE," MARK SAID. "YOU PUT THIS SIDE BY SIDE WITH A LEGACY SONEX AND JUST THE LINES OF THE COWLING AND EVERYTHING ARE MUCH MORE VISUALLY PLEASING."

"I think at the end of the day we ended up with a much better-looking airplane," Mark said. "You put this side by side with a legacy Sonex and just the lines of the cowling and everything are much more visually pleasing." *EAA*

Megan Esau, EAA 1171719, is EAA's staff writer, regularly contributing to both print and digital publications. She's an aspiring pilot, a passionate aviation enthusiast, and an avid learner of just about everything. E-mail Megan at *mesau@eaa.org*.



XENOS-B MODEL

On January 4, 2017, Sonex announced the production of the new Xenos B-Model kit, which will include many of the same enhancements as the Sonex and Waiex B-models, including more space, engine options, and fuel. The Xenos is a motorglider variant of the Waiex with more than twice the wingspan, nearly 46 feet when set up for soaring. The wings support interchangeable aerobatic wingtips that reduce the span to a little less than 40 feet. In either configuration, the Xenos can be flown either as an LSA or by glider pilots with a self-launch endorsement. The traditional AeroVee/AeroVee Turbo and Jabiru engine mount options will continue to be available, along with the added choice of mounts for ULPower and Rotax 912 series engines. The Xenos B-Model fuel tank can accommodate four more gallons of fuel than the original model, offering room for a total of 20 gallons of fuel. Shipments on the Xenos B-Model were slated to begin in March.

Cost of complete airframe kit: $27,495.

PHOTOGRAPHY BY **ERIN BRUEGGEN**, ILLUSTRATIONS COURTESY OF **SONEX AIRCRAFT**

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EAA EXPERIMENTER FEATURE

TAIL WHEEL GEOMETRY

FACTORS TO CONSIDER WHEN DESIGNING YOUR TAIL WHEEL SETUP

BY MICHAEL LEIGH

IMAGINE AN AIRPLANE HURTLING down the runway with all three wheels planted on terra firma. The pilot has landed and just lowered the tail wheel. Now assume she encounters a disturbance that pushes the airplane sideways. This disturbance can be a sudden gust of crosswind, a runway sloped off to the side, rough turf, or some turning accelerations. What will happen next?

Parts breakdown before welding.

PHOTOGRAPHY COURTESY OF **MICHAEL LEIGH, KELSEY KAISER**

FIGURE 2:
Tail wheel geometry using the "captain's tiller" model.

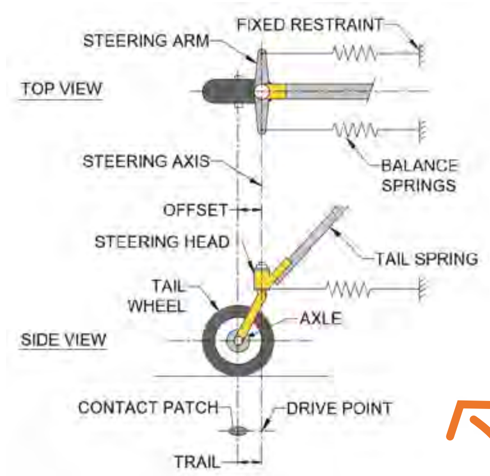


Figure 1 shows the response we might expect from a sudden gust acting on the side of the fuselage. As can be seen, the side force causes the tail wheel to deflect out of the wind, turning the airplane's nose into the wind. The center of this turn is at the intersection of the main gear and tail gear axle projections. Once the turn develops about this center of rotation, centrifugal forces acting at the airplane's center of gravity create an additional force to the outside of the turn. We have an ever-tightening turn if not corrected by pilot intervention. In our training, we have been cautioned about the "weather vane" effect, and live with it as a fact of life. Tail wheel mechanics is a subject that obeys the laws of science. As such, there is no magic or art involved. Here are some of the factors to consider when designing your tail wheel setup.

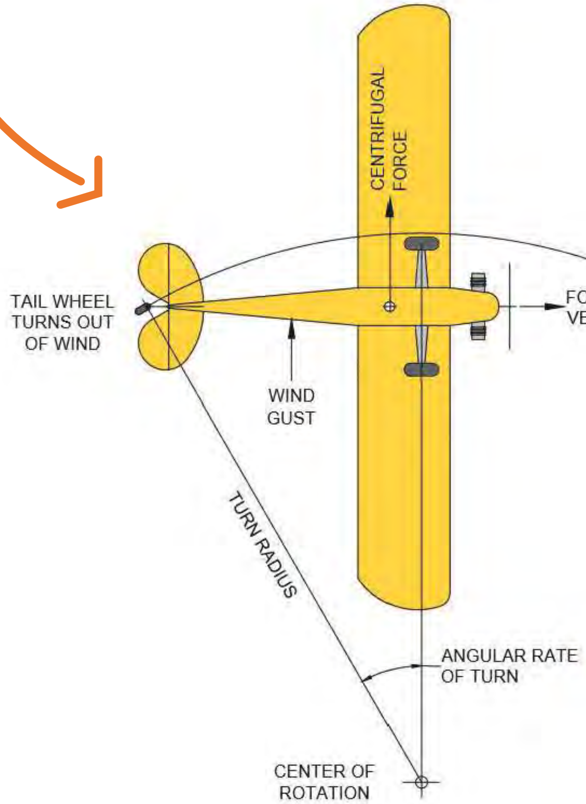


FIGURE 1:
Classic model for tailwheel airplane ground-handling dynamics.

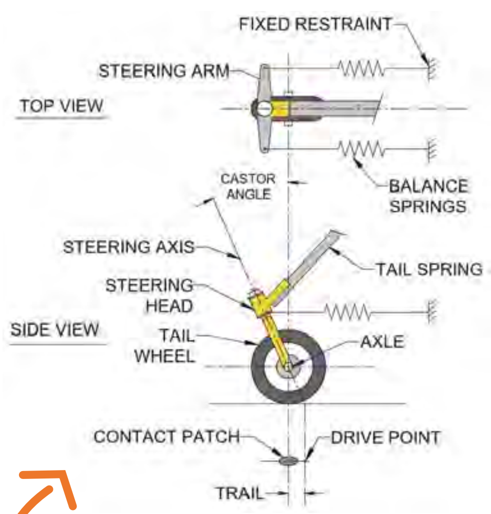
Shown in Figure 2 is a typical tail wheel arrangement. The steering axis is vertical or nearly so. A projection of the steering axis to the runway surface describes the point about which the tail wheel will pivot. This intersection is labeled the drive point. The axle is offset to a position behind the steering axis. The weight supported by the tail wheel will create a contact patch beneath the tire. As you can see, the contact patch trails behind the drive point. If the drive point were moving forward, the contact patch would follow directly behind. Likewise, if pushed sideways, the wheel would turn into alignment with the drive point and cause the airplane to turn.

A freely pivoting tail wheel would have no directional stability. Balance springs can be added to the assembly to counteract the wheel's turning tendency about the steering axis. For the moment, let's assume that the springs are anchored firmly to the fuselage tail section so that the tail wheel tracks straight ahead by spring tension. This would never be the case while actually landing an airplane because the pilot's steering inputs should never be impeded. However, this fiction conveniently limits the number of variables entering our control system to simplify the conversation.

A parameter that determines how religiously the tail wheel turns into alignment with the drive point is labeled as the "trail" dimension. If this dimension were increased by increasing the axle offset, for example, the drive point exerts a greater turning advantage over the tail wheel.

ILLUSTRATIONS COURTESY OF **MICHAEL LEIGH**

FIGURE 3:
Tail wheel geometry using the "biker's rake" model.



Shown in Figure 3 is an alternative arrangement. As you can see, the axle position falls directly in line with the steering axis, making the offset zero. However, the steering axis is tilted by the caster angle. Again, the projection of the steering axis onto the runway falls at a point ahead of the contact patch. The wheel will turn as required to follow the drive point. If the trail dimensions are the same in both cases, we can conclude that both tail wheel arrangements are functionally equivalent. Also, being equivalent, both of these geometries will suffer the same deficiencies. To know what deficiencies exist, it is necessary to describe a desired tail steering response.

First, the airplane should be able to resist the effects of side disturbances. The disturbances include but are not limited to wind gusts, runway sloped off to the side, and lateral accelerations due to turning corrections possibly initiated by the pilot.

The response of the airplane should not exhibit oversteer or understeer tendencies. Having to "dance" on the rudder pedals is a symptom of oversteer. With oversteer, once a turn is initiated, a quick application of opposite rudder is required to stop it. Conversely, understeer is the need to continually add more and more pedal to keep the turn going. With neutral steering the airplane turns at a rate that matches the pedal deflection. Neutral steering gives the airplane a predictable response.

The pedals should have conventional "feel." That is, a tighter turn should require greater pedal force. Force feedback due to lateral disturbances should not appear at the pedals.

Finally, the tail wheel should be self-centering. With no input from the pilot, the tail wheel should seek an alignment that tracks the longitudinal axis of the airplane.

Looking at the main gear for a moment, the pneumatic tire, contrary to most assumptions, rolls in two directions. Naturally, the tire rolls around the axle. However, with a side load the tire tends to roll sideways, too. Figure 4 shows a main wheel loaded by aircraft weight and a side force. This continual giving way makes the tire "walk" to the side as it rotates. Instead of moving exactly forward, the tire travels at a sideslip angle.

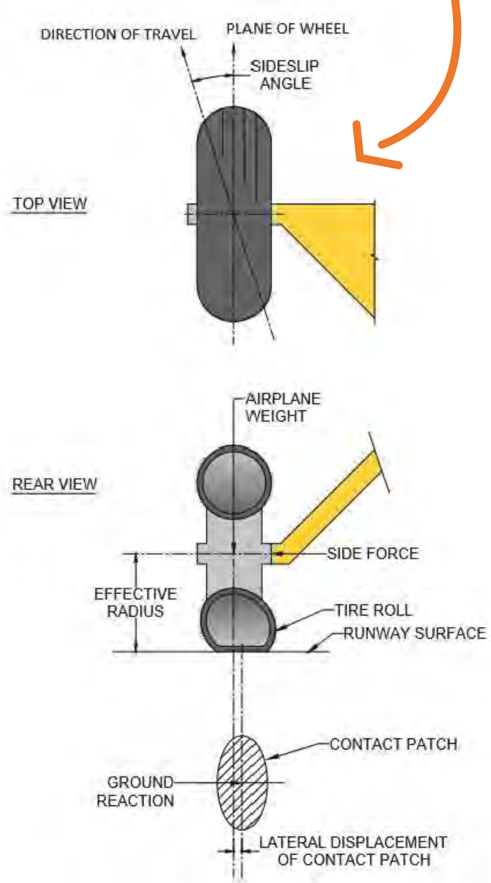


FIGURE 4:
Pneumatic tire rolling sideways.

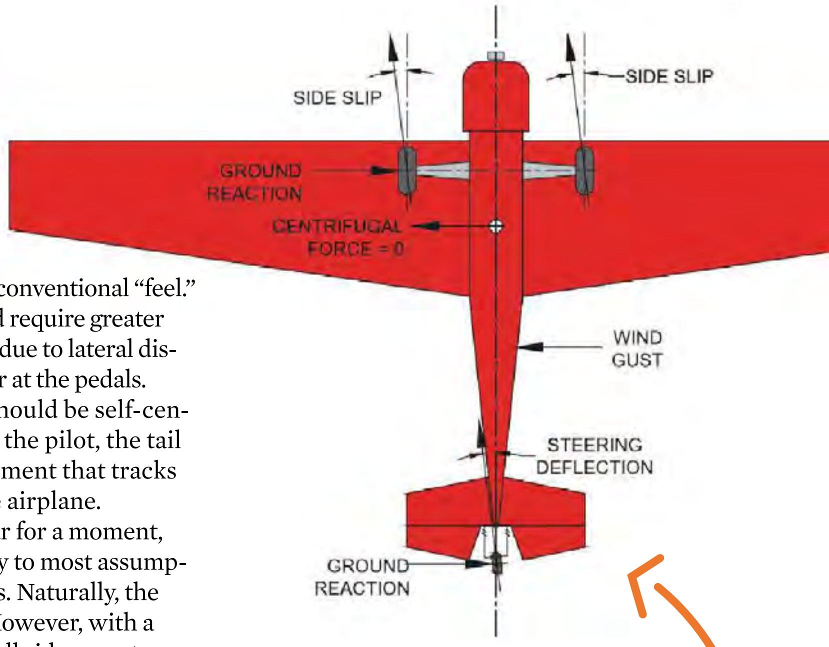


FIGURE 5:
Airplane response with improved tail gear design.

In Figure 5, an airplane on landing roll experiences a sudden gust. Based on where the center of gust pressure acts, some force is reacted to at the main gear and some by the tail wheel. The portion of the side load carried by the main wheels causes them to sideslip at an angle. Due to careful design, the portion of the side load imposed upon the tail wheel causes it to deflect at an equal angle. The airplane drifts to the side, but does not turn. With no turning rate, the centrifugal force is zero and the airplane does not oversteer.

Using what we know, a steering geometry is proposed in Figure 6 that promises to fulfill the requirements for good ground handling. There may be other geometries that are just as useful for special purposes. As you can see, the trail dimension has been reduced so that the tail wheel is more immune to side disturbances. However, the drive point remains slightly ahead in the contact patch. A side load at the steering head creates a light turning moment that can be easily balanced by a calibrated deflection of the steering springs. The slight steering angle change, along with main tire sideslip causes the airplane to stay pointed straight without generating inertial forces. The relative insensitivity to disturbances reduces the force feedback at the pedals.

ILLUSTRATIONS COURTESY OF **MICHAEL LEIGH**

The right side of Figure 6 shows the wheel turned at 90 degrees. Due to the offset and caster angle built into this arrangement, the stance of the tail must raise as the tail wheel is turned to either side. This has the effect of requiring more pedal force for a tighter turn. With a relaxation of pedal force, the tail wheel will roll into the "groove," aligning itself with the longitudinal axis of the airplane.

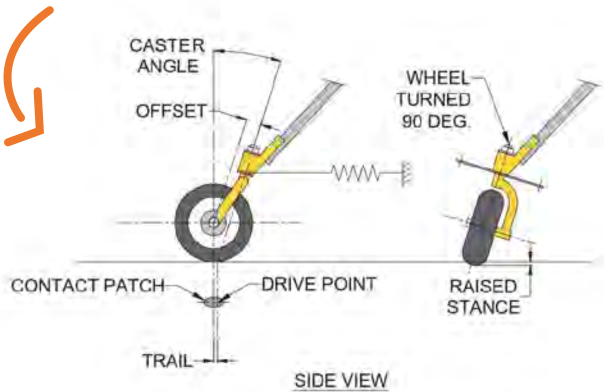


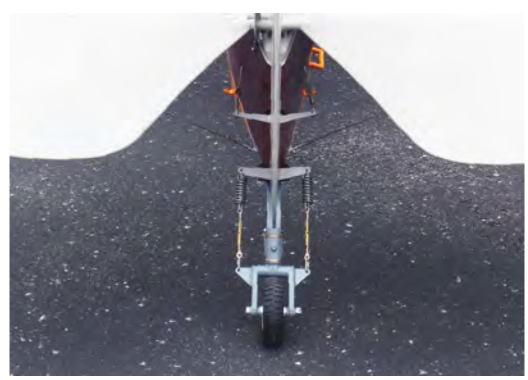
FIGURE 6:
Reconfigured tail wheel geometry for side load immunity.

In conclusion, the main reason for the unruly behavior of tailwheel airplanes is attributed to excessive oversteer in the handling response. It is important to limit the amount of trail built into the steering mechanism. Too much trail makes the steering sensitive to external disturbances, which in turn sets up aggravating inertial forces. Compensation for external disturbances by suitable geometry reduces the pilot's workload.

The tail wheel shown in Figure 7 incorporates the suggested geometry and produces a predicable steering response on the ground. The rearward slope of the steering axis causes the pivot point to fall close to the contact patch, thereby reducing the trail dimension. The side force immunity can be demonstrated by pushing on the side of the fuselage. The tail wheel shows little desire to turn out of our "simulated crosswind," preferring to stay steady on course. This in no way interferes with the pilot's ability to steer the tail wheel, yet eliminates the distracting force feedback due to side load disturbances. EAA

Michael Leigh, EAA 88632, is a product of the Aviation System program at the University of Tennessee Space Institute. Based at the Tullahoma Regional Airport, he serves as vice president of EAA Chapter 458 and the fabricator of a Baby Ace airplane. Michael currently works as electronics engineer in flight control augmentation for the innovative start up Flight Level Engineering LLC.

FIGURE 7:
Tail wheel assembly fabricated by author incorporating the suggested design features.



Above: *Steering springs adjusted for accurate longitudinal tracking.*

Right: *Negative caster as shown here provides side load immunity.*

Below: *Author shows how tail wheel can be turned 90 degrees against steering spring tension.*

PHOTOGRAPHY COURTESY OF **MICHAEL LEIGH**

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PHOTOGRAPHY BY **CINDY LUFT**

Two Weeks to Taxi

Washington *Glasair Sportsman*

AFTER MORE THAN 45 YEARS in the same Cessna 172, it seemed time for a major change. With my teenage daughter, Grace, working on her private certificate and with two grandsons, Ian and Angus, all of whom are good at mechanical things, it crossed my mind to look into something new from the aviation world to share.

I'm glad I did, because then I stumbled onto the Glasair Two Weeks to Taxi program. Harry DeLong at Glasair suggested I build the Sportsman kit at the Arlington, Washington, factory as part of Glasair's annual Build-a-Plane challenge. The challenge was also sponsored by the General Aviation Manufacturers Association (GAMA), and the Sportsman is just what I needed: a four-place, modern design with advanced avionics suitable for tricycle or tail-dragger wheels, floats, or amphibs, VFR or IFR avionics, etc.

Watch the entire build through a time-lapse video at *EAA.org/Extras*.

Glasair had invited students in science, technology, engineering, and mathematics (STEM) programs from more than 70 U.S. high schools to participate in its challenge to build a better-performing airplane by a specific set of criteria. The winning team in 2016 was four students and their teachers, Michael Hansen and Jerry Graf, EAA 295425, from a high school and STEM program in Weyauwega, Wisconsin. Their entry won them a two-week trip to the Pacific Northwest, and we won their assistance with our project at the Glasair factory.

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Since the Build-a-Plane challenge fit exactly my goals for my own family members, and the price was still within reach and significantly below that of a comparable certified aircraft, it was definitely a win-win situation. And we all learned a lot and had some fun.

A few minutes after 7 a.m. on a Monday, we assembled in a circle at the factory hangar with six professional techs led by Ryan Flickinger. Each day we started off with a demonstration by Ted Setzer who is a factory expert on topics such as fiberglass molding and repairs, nuts, bolts and fasteners, wiring and connectors, riveting, and the history of experimental aircraft business.

We worked in groups of two to four, each with an experienced tech. Everyone rotated through each group taking part in each step. We assembled the firewall and empennage and installed the engine, landing gear, fuel tanks, wiring, pulleys and cables, plumbing, cockpit panel and rigging, windows, and doors. You can watch a video of the wing folding at *www.EAA.org/extras*.

Everything was documented, and many steps were photographed, on more than 30 multipart checklists seen and initialed by one of the techs and by me. At the end of each day we reassembled our circle, and Ryan summarized our progress. You can see the airplane grow before your eyes in a 90-second time-lapse video at *www.EAA.org/extras*.

Initially things went together quickly. Some subassemblies were partially completed before we started, e.g. the inner steel tubular cage surrounding the cabin space; the instrument panel was mostly assembled and ready to install and plug in; and the two halves of the fiberglass fuselage were fused together and anchored to the steel cage.

Another important component of the experience was that several executives from major corporate sponsors were present and shared their perspectives, experience, and flying skills with all of us. How many high school-age pilot wannabes and aviation fans have actually built an airplane and even flown one with a Boeing or Jeppesen vice president or a GAMA CEO?

We worked from early morning until 5:30 p.m. daily, with extravagant lunches hosted by the sponsoring companies. It took me six weeks to work off those lunches after the build was over! On Friday of the second week, the FAA inspector and his efficient partner arrived in the middle of the day and set up at a table nearby. He went through the checklists and performed a careful walk-around looking into open inspection ports, checking for looseness, unnecessary tightness, tools left inside hard-to-reach places, bad rivets, missing witness paint marks, and telltale signs of fuel, oil, or vent leaks. He did find one or two things needing attention, but that's all! We had built a "tight ship" and now had an FAA airworthiness certificate.

Later that same day we opened the hangar doors, rolled it out, and lit it off. The Lycoming IO-390 fired right up. I taxied the plane out to the runway to prove it could be done.

There were still things to do: a few adjustments, 40 hours of solo flight, then disassembly and off to the paint shop. After reassembly, N653LG was ready for passengers. I now look forward to traveling to Weyauwega to share it with the team members there.

Dennis Willows, EAA 1228004; Friday Harbor, Washington
E-mail: *dwillows@u.washington.edu*

NEW MEXICO
WITTMAN BUTTERCUP

THIS REPLICA of the Steve Wittman Buttercup was first flown at Moriarty, New Mexico, on my 87th birthday, October 3, 2016. While Steve flew his raceplane to the races, his wife flew supplies in the Buttercup. This is the last version of many experimental modifications of engines, props, and flat spring, tapered rod landing gear. The Buttercup was the predecessor to Steve's 1953 Tailwind, which has a similar shape but is slightly smaller, with more power for higher performance.

The raw materials came from Aircraft Spruce including spruce for spars and wing ribs, steel tubing, aluminum sheet, etc. I built the Corvair 164-cubic-inch 100-hp engine with William Wynne components; the Corvair 5th Bearing Kit carries the Warp Drive prop loads. The fabric with the Stewart Systems adhesive, UV barrier, and color topcoat waterborne materials were a pleasure to work with — no fumes.

For assembly alignment, the fuselage was leveled in the center of the shop, wings hung on chains with long eyebolts for fine adjustment of angle of attack and dihedral, then wing root and struts fitted in place. My modifications were to counterbalance the elevator and ailerons. I also designed the wing leading edge hinge point location to be only 3/4 inch below the wing surface for the same deflection as the "head banger" original hinge struts that projected 4 inches below the wing. Steve was quoted as saying that these struts were the only hazard of the plane. Lights are all LEDs, with lenses molded in the kitchen oven. Many small parts were designed and built to fit.

There was so much to learn to build a tube frame, wood rag-wing with classic technology. Certainly this was a major educational experience, very enjoyable, and satisfying.

Dan Palmer, EAA 3065; Tijeras, New Mexico
E-mail: *danpal@swcp.com*

MISSOURI
STINSON 108-1

SOME THINGS IN LIFE go full circle. In this case, I am referring to NC8841K, a 1947 108-1 Stinson. This Stinson was owned by a family friend based at our local airport when I was a kid, and was the very first four-place airplane in which I rode. In March 2014, a friend of mine called to tell me he was helping a widow in Texas liquidate her husband's estate. This Stinson was part of that estate.

I was highly interested in it so I went to look at it and was amazed at its condition. I made up my mind that this Stinson needed to come back to Queen City. Once it was back, its fabric was rejuvenated and shot with Santa Fe Red Randolph butyrate dope. The metal surfaces were stripped and painted. The 150-hp Franklin engine was removed and shipped to Airworx in Brewton, Alabama, for a major overhaul.

Today the airplane still sports its original interior, which is in remarkable condition despite its age. In 2015 it won the Preservation Award at EAA AirVenture Oshkosh as well as the NeoClassic Grand Champion award at the Antique Airplane Association's annual convention in Blakesburg, Iowa. At AirVenture 2016 it received a Bronze Lindy Award. The plane I first flew in as a little boy will remain in my possession until I can no longer fly it. It's home.

My sincere appreciation is extended to many people. Larry Phelps and Alvin Musser get credit because without them I would not have this Stinson. Gene Fox and Gale Stock were instrumental in helping with the refinishing process. Leo Fox was always available to lend a hand wherever needed. Chris Collum at Airworx built a truly fantastic engine. Most of all, I appreciate the support my wife, Carolyn, gives me in my bad habit of old airplanes.

Paul Applegate, EAA 96958; Queen City, Missouri
E-mail: *carolynapplegate@hotmail.com*

OREGON
VAN'S RV-7

IN JULY 2009, my son Trevor and I were somewhere over Montana in a 182 going to AirVenture. Out of the blue, he asked if I was up for a "father-son project" — building an airplane. I am not as technically savvy as Trevor and never had a desire to undertake such a project, but in September the tail kit arrived and we started building. After two years building the standard kits for tail and wings, we opted to save time by going with the quick-build fuselage when we were ready.

Trevor was the driving force behind the airplane while I was the dutiful assistant bucking rivets, deburring holes, fluting ribs, and the other "mundane" parts of the build. We both learned a great deal, and I have to say it was an enjoyable project — especially doing this with my son.

We got our transition training from Mike Seager in March of 2015, and in April N781TD took to the air for the first time. Our friend and build mentor the late Joe Blank of Van's Aircraft did the first flight before Trevor and I took our turns. The 40-hour flight-test phase was nearly squawk-free, and that July the airplane made its first trip to AirVenture. The airplane is a joy to fly, and more trips to Oshkosh are planned for the future.

Power is from a YIO-360 engine driving a Hartzell two-bladed blended airfoil prop. We get an honest 166 knots true airspeed burning 8.5 gph. Our interior is from Classic Aero Designs, paint is by Art Craft, and we are very happy with both. We have an IFR panel with dual 10-inch Advanced Flight Systems EFIS displays, a Garmin avionics package, and a Vertical Power electrical system.

Our thanks to Van's Aircraft for a fantastic airplane, to Joe for his help and guidance, and of course to our wives for putting up with all of our nights and weekends working in the hangar. Luckily, they enjoy the airplane as well. *EAA*

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Gone West

Not alone into the sunset but into the company of friends who have gone before them.

ALABAMA
Wayne Schober (EAA 523772), Mobile

CALIFORNIA
Timothy Foley (EAA 302667), San Mateo
Terry Gibson (EAA 464880), Ventura
Thomas James (EAA 306427), Livermore
Bentley Nelson (EAA 754359), San Rafael
Joann Osterud (EAA 89680), Oxnard
Robert Pursel (EAA 578434), Fremont
William Spriggs (EAA 125516), Santa Paula
Eugene Turner (EAA 3648), California City
Paul Wallace (EAA 19804), Jackson

COLORADO
Cleon Biter (EAA 399481), Longmont
Eugene Horsman (EAA 48821), Golden

FLORIDA
Joseph Miller (EAA 596822), St. Augustine
George Psiropoulos (EAA 8173), Holiday
Ted Rypchinski (EAA 1167017), The Villages
Joseph Starling (EAA 1158632), Lawtey

ILLINOIS
Fred Finck (EAA 480868), Alton
Ron Henderson (EAA 284268), Springfield
Ron Okerson (EAA 450366), Golconda

KENTUCKY
Wayne Hagan (EAA 484113), Paducah

MASSACHUSETTS
Alan Lavender (EAA 1092527), Newburyport

MINNESOTA
David Granneman (EAA 437094), Coon Rapids
Matt Hayes (EAA 1207333), Lakeville
Robert Kurkowski (EAA 281281), Mankato

MISSOURI
M. "Lee" Arnold (EAA 1488), Black Jack
Gail McCool (EAA 740762), Sparta

NEW HAMPSHIRE
Roger Scott (EAA 455385), West Ossipee

NEW JERSEY
Louis Bognar (EAA 702923), Franklin Lakes
Jack Kettener (EAA 603436), Bordentown

NEW YORK
Steven Yuhasz (EAA 305), North Tonawanda

NORTH CAROLINA
Henry Balch (EAA 300432), Hendersonville
James Ballard (EAA 107649), Conover
Richard Bills (EAA 486331), Columbus

OHIO
Donald Tritch (EAA 9009296), Findlay
Thomas Vogelpohl (EAA 374027), Cincinnati

OKLAHOMA
Alvin Steinke (EAA 799247), Welch

PENNSYLVANIA
Janice McGeary (EAA 854693), Allison Park

SOUTH CAROLINA
Jim Balderson (EAA 757895), Greenville
Howell "Nick" Jones (EAA 16380), Sheldon

SOUTH DAKOTA
Harry Hybertson (EAA 201587), Sioux Falls

TEXAS
Aubrey Barlow (EAA 434566), Jasper
Guy Knolle (EAA 573101), Lakeway
Michael Rayburne (EAA 861423), Fort Worth

UTAH
Ricci Martin (EAA 1078835), Salt Lake City

VIRGINIA
James Bigler (EAA 301760), Martinsville

WASHINGTON
Ron Rankin (EAA 39663), Yakima
Harry Watkins (EAA 15633), Anacortes

WISCONSIN
Patrick Collins (EAA 252939), Green Bay
Lyle Kahler (EAA 488956), Reedsburg
Terry Kohler (EAA 243098), Sheboygan

WYOMING
David Burgeson (EAA 567487), Alpine

AUSTRALIA
Frederick Long (EAA 114581), Bayswater, Western Australia

CANADA
Terry Gibbons (EAA 1082835), Midland, Ontario
Camille Robinson (EAA 281362), Kenora, Ontario
Walter Wiegels (EAA 75277), Hamilton, Ontario

UNITED KINGDOM
David Johnstone (EAA 350454), Tutbury, Staffordshire, England

2 Millionth Young Eagle Solos

MANY CONGRATULATIONS to EAA's 2 millionth Young Eagle, Jodie Gawthrop, EAA 1108302, who completed her first solo on March 9, less than a year after her flight with former Young Eagles Chairman Harrison Ford.

"Soloing was an empowering experience, and being in complete control of the aircraft was unlike anything I had ever felt before," Jodie said. "It featured an unforgettable mix of both thrill and responsibility."

After participating in the Civil Air Patrol's orientation program in 2013, Jodie fell in love with aviation and has made it her mission to take to the sky; she's even considering pursuing a military career.

She credited this milestone accomplishment to EAA; her CFI Dave Hooper, EAA 439937; and the general aviation community at large.

"Their unwavering support has motivated me to study hard on the ground, aim for excellence in the air, and strive to become a better person overall," she said.

ALUMINUM CAN BUILT MINI-MAX

BY DAVID LEITING, EAA LIFETIME 579157

RON DETERT has not gone a day without longing to be airborne. In his own words, "I am 82 years old and still anxious to fly!" However, life has not always dealt Ron the cards needed to own an airplane and become a pilot. But with the help of some ingenious fundraising, EAA Ultralight Chapter 75, EAA Chapter 640, and the rest of the Wausau, Wisconsin, aviation community, Ron has been able to chase his lifelong dream.

In 2002, he decided it was time to begin down the path of owning his own airplane. However, with an ill wife at home and limited funds, Ron thought to himself, "I have to build my own, but how?" He settled on building a Mini-Max, but was in need of more money and resources.

Shortly after the bench for the build was ready, Bill Markstrum, EAA 90501, a fellow member of Ultralight Chapter 75, was at a family reunion when he noticed all of the attendees throwing away their used aluminum cans. Bill decided he would start saving his aluminum cans so that Ron could turn them in for credit to fund his Mini-Max.

In the early stages of the can saving Syd Cohen, EAA Lifetime 98446, offered the garbage barrels in his hangar as a collection point for the cans. As the word of Ron's aluminum can fundraiser began to spread, Syd's hangar became the dumping ground for aluminum cans collected by the Wausau airport community, Chapter 640, and Ultralight Chapter 75.

As soon as the eight barrels in Syd's hangar were full, Ron would make a trip to the local scrap facility. On a typical visit, Ron would make roughly $20 to $30, which he immediately put toward aircraft parts. Once the parts were ordered, he would work on his Mini-Max until he was able to make another trip to the scrap yard. Little by little, Ron made progress on his project. Even if it was just a $30 purchase of AN bolts here or a $28 purchase of wood there.

While the fundraising continued, Ron started to get larger donations. There would be days he would show up to the airport, and there would be four or five bags of aluminum cans stacked outside of Syd's hangar.

Pilots from far northern Wisconsin would load up their aircraft with garbage bags full of aluminum cans and fly down to Wausau just to donate the cans to the project. Steve Kruger, president of Ultralight Chapter 75, even donated the scrap aluminum from his Quicksilver MX so that Ron could have the funds from that scrap. Ron described the kindness of these donations as "the EAA spirit; we are here to help one another, whether we are friends or strangers."

Ron continued to chip away at his Mini-Max until 2013 when his wife succumbed to her illness. During this time, he took a rather lengthy break from building, but the itch to finish his project would not stay away for long.

As Ron got back to work on the airplane, the project became more financially stable, allowing him to work at a quicker pace. At this point, Ron knew it was time to pass along his "Aluminum Can Airplane Fund Enterprise," as he called his unique fundraiser, to another deserving builder.

It did not take long for Ron to find the next candidate: Jack LaSee of Mosinee, Wisconsin, is 18 years old, and as is the case with many folks at this age, the financial barrier is one of the biggest hurdles to clear when building an airplane.

Jack started his project, a Pietenpol, when he was 15 years old and has since nearly finished the fuselage and tail feathers; both sections just need to be covered.

As for Ron's Mini-Max, he completed the project in the summer of 2016 with roughly 15 percent of the cost having been covered by aluminum can donations. Since Ron will operate his Mini-Max under FAR Part 103 and has not had much flight training recently, he did not want to conduct the first flight. In his place, Steve made the first flight on August 8, 2016.

Steve, a CFI and the proud owner of an Aeronca Champ, has agreed to give Ron the flight training necessary to safely operate his Mini-Max. "Steve said that he will not even let me taxi the Mini-Max until he's satisfied with my skills in his Champ, which I agree with wholeheartedly because EAA is all about safety, safety, safety," Ron said.

To Ron, the support he's received on this project represents exactly what EAA stands for. He could not express enough that without the support and knowledge of his fellow EAA chapter members, his project would have never made it to the sky. Ron wants aspiring builders and pilots to know that all it takes is "desire, perseverance, love, and the EAA spirit" to make your aviation dream become a reality.

SEAREY SOLO AROUND THE WORLD

MICHAEL SMITH, EAA 1001669, of Williamstown in Victoria, Australia, recently finished a flight that most of us could only dream about: a trip around the world in his Searey named *Southern Sun*, a two-seat amateur-built seaplane. The flight was the first circumnavigation by a solo pilot in a flying boat and earned him the title of Adventurer of the Year, awarded by the Australian Geographic Society.

Smith didn't set out to go around the world; a longtime student of aviation history, his original goal was to retrace the steps of the Qantas Empire Airways/Imperial Airways flying boats that flew from Sydney to London in the late 1930s. After months of meticulous planning, he departed on April 12, 2015. Sixty days and half that many stops later, he touched down at Damyns Hall Aerodrome on the outskirts of London. Mission accomplished, he was starting to make arrangements to have the *Southern Sun* shipped home when his wife suggested that he just fly it home — the long way. And so it was that his two-month flight turned into seven, making 80 stops in 25 countries and logging 480 hours of flying time.

Smith is working on a book about his experiences, as well as a feature-length documentary. Read more about these projects and the original epic adventure by visiting *www.EAA.org/extras*.

WELCOME, NEW EAA CHAPTERS

EAA's local chapters are about people, bringing together individuals interested in learning more about aviation as well as sharing their own knowledge. To find a local chapter and get involved in grassroots recreational aviation in your own backyard, *see EAA.org/chapters*.

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EAA CHAPTER 812 HOLDS ALL-FEMALE YOUNG EAGLES EVENT

IN HONOR of International Women's Day, EAA Chapter 812 in Ocala, Florida, participated in a special Young Eagles rally specifically for girls. The rally, held March 11, was part of a Women of Aviation Week event, an initiative of the Institute for Women of Aviation Worldwide (iWOAW), organized locally by CarolAnn Garratt, EAA 58437.

"I was invited to be a speaker four years ago at one of these [Women of Aviation Week] events in Canada and was convinced that this was the way to get girls interested in aviation," Garratt said. "Since then, I have teamed with EAA Chapter 812 to run this event."

According to Chapter 812 Young Eagles Coordinator Warren Levin, participants in the Girls Fly event are given a Young Eagles ride, ground school, and a tour of the airport's air traffic control tower. The day finishes with a career session.

"The career session really seems to be a big hit with the girls and their parents," Garratt said. "This year, one girl signed up with the local flight school immediately after our session finished."

Only about 6 percent of pilots are female, and Garratt said getting girls involved in aviation is important to increase the number of pilots worldwide.

"One of the things that convinced me, back in 2014 when I attended the first event, was what I learned about how girls learn and do things," Garratt said. "They tend to learn and participate in groups. If one or two girls participate in a 'normal' Young Eagles event, usually with 20 or more boys and six or seven male pilots, they realize immediately that this is a 'guy' thing. We take a day to show them that this is a 'girl' thing. It gets them excited and interested."

This year's Girls Fly drew in 23 young women from the Ocala area, and Levin said drawing a large group is typical for all of the chapter's Young Eagles rallies. Next year, Girls Fly will be held on March 10. EAA

WELCOME, NEW LIFETIME MEMBERS

Frank Borman (EAA 300174), Billings, Montana
Susan Borman (EAA 1232990), Billings, Montana
Tricia Coletto (EAA 1103781), Northport, New York
Terry LaRue (EAA 1108931), Ellensburg, Washington
Sean Lynch (EAA 1213400), Brighton, Illinois
John Moran (EAA 786786), Wellington, Florida
Charles Nestal (EAA 1027661), Albuquerque, New Mexico
Mary Pratt (EAA 800572), Henderson, Nevada
Richard Pratt (EAA 800571), Henderson, Nevada
Jonathan Ross (EAA 135637), Northport, New York
John Sylvester (EAA 497210), Hereford, Arizona

Bending Sheet Metal

What you need to know to save time and material

BY CAROL AND BRIAN CARPENTER

WE ARE OFTEN SURPRISED by the number of aircraft builders who seem to be intimidated by the process of calculating bend allowance and setback and simply creating a flat layout for bending a simple part. In this article we are going to back up a bit and provide some of the theory necessary to understanding how we go about the process of converting a flat piece of sheet metal into a complex component. Learning to accurately lay out and bend sheet metal is a very useful exercise. Once you have mastered the process, you will find that it not only saves a great deal of time, but also can save you a great deal of wasted material.

To start with, let's examine some of the properties of aluminum sheet metal used in aircraft. The two most common alloys of aluminum used in the experimental aircraft world are 6061-T6 and 2024-T3. Aluminum 6061 is one of the least expensive and most versatile of the heat-treatable aluminum alloys with a tensile strength of approximately 40,000 psi. It has good corrosion resistance in comparison to 2024-T3, and current cost per square foot of 0.040 inch is $2.53. On the other hand, 2024 is one of the best known of the high-strength aluminum alloys. With its high strength, about 50,000 psi tensile strength in the T3 condition, it is used on structures and parts where good strength-to-weight ratio is desired. Since corrosion resistance is relatively low, 2024 is commonly used in clad form (Alclad) with a thin surface layer of high purity aluminum. The cost of 2024-T3 is about 50 percent more than 6061-T6 aluminum at about $3.94 per square foot of 0.040-inch sheet.

Understanding the properties of each of the aluminum alloys, in particular, the malleability and ductility, becomes very important during the sheet metal layout and bending process. By definition, ductility is a solid material's ability to deform under tensile stress. And malleability is a material's ability to deform under compressive stress. The ductility of 2024-T3 is about 18 percent. When bending aluminum around a radius, we can see that we are both stretching one side of the aluminum (ductility) and compressing the other side of the aluminum (malleability).

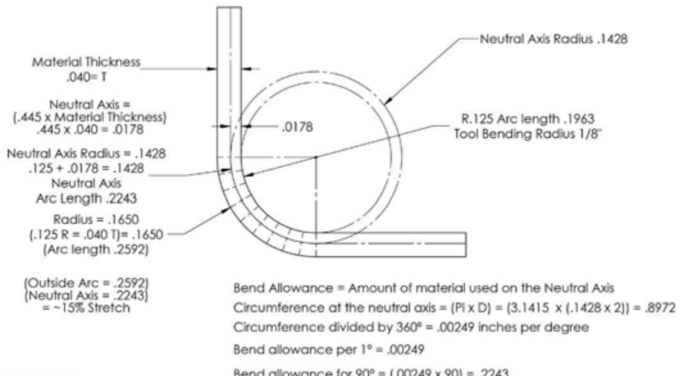


Figure 1

(Figure 1) Extensive testing has shown that the "neutral axis" (under neither compression nor tension) during the bending process is about 0.445 times the thickness of the material. The smaller the radius that the metal is bent around, the greater the differential between the neutral axis and the outside arc of the skin. Additionally, the greater the thickness of material, the greater the differential between the neutral axis and the outside arc of the skin. Stretching the outer skin beyond its limits will normally result in cracking. Of course, there isn't a necessity for calculating the minimum bend radius because most sheet metal manuals, including Advisory Circular 43.13-1B, have a minimum bend radius chart available for quick reference. (Figure 2)

The tool we use for bending sheet metal is called a "brake." A sheet metal brake used for aircraft aluminum has either fixed or interchangeable jaws with a very specific radius built into the jaws. In our shop, we use a 1/8-inch radius that allows us to bend up to 0.063-inch 6061-T6 aluminum. This allows us the ability to bend the majority of sheet metal sizes used in small experimental aircraft. Understanding the necessity of using a radius during the bending process will, now, help us to understand how to calculate bend allowance. Bend allowance is nothing more than the amount of material that is used for the bent portion of the sheet metal. The radius of the bend at the neutral axis is the tooling radius plus 0.445 times the thickness of the sheet metal. Multiplying the radius times two will give us the diameter, and multiply that times pi (3.1415) will give us the circumference. Taking the circumference and dividing by 360 degrees will leave us with a dimension per 1 degree of bend. Multiplying that by 90 degrees will give us the bend allowance for a 90-degree bend. (Figure 1)

ILLUSTRATIONS COURTESY OF CAROL AND BRIAN CARPENTER

Minimum Bend Radius		
Material Thickness	6061-T6	2024-T3
0.020	1/16	1/16
0.025	1/16	1/16
0.032	1/16	3/32
0.040	3/32	3/32
0.050	3/32	1/8
0.063	1/8	5/32
0.080	3/16	1/4

Figure 2

Although the process of calculating bend allowance is relatively simple, it's made even easier by the use of a bend allowance table. A bend allowance table has a matrix of the most common sheet metal sizes and the standard bending radii already calculated for both a 1-degree bend as well as the most common 90-degree bend. A bend allowance table can be found in AC 43.13-1B.

When we prepare a piece of metal for bending, we are doing what we call a flat layout. All sheet metal components are simply a series of flat sections and bends. Prior to bending up a sheet metal part we get out a piece of scratch paper and simply formulate a layout similar to what we see in Figure 3. We will lay out each flat section with the bend allowance required for each of the bends. In this case, because the bends are all 90 degrees, the material thickness is the same, and the radius for each of the bends is also the same; we only need to calculate or look up bend allowance once. The amount of material (bend allowance) used for each of the bends is identical. Next we simply need to calculate the length of each one of the flat sections. The normal formula for calculating the flat section is given dimension minus setback. Setback is the radius plus the thickness used during the bend. If all given dimensions were measured from the outside of the material to the end of the flat section, this formula would work great. However, there are many cases where you're going to have to extrapolate on this formula to calculate the flat section length. For example, to calculate the length of FLAT A, the given dimension is from the inside of the bend.

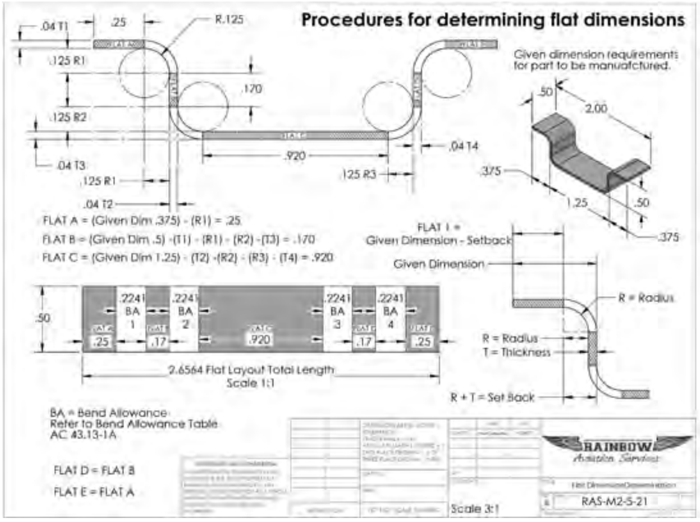


Figure 3

In this case FLAT A equals the given dimension of 0.375 minus the bend radius of 0.125, which equals 0.25.

To keep comprehension to a higher level, we normally start by teaching bend allowance as we have shown here, with all bends being conducted at 90 degrees. Once we have mastered the process calculating for 90-degree bends, we can venture

ILLUSTRATIONS COURTESY OF CAROL AND BRIAN CARPENTER

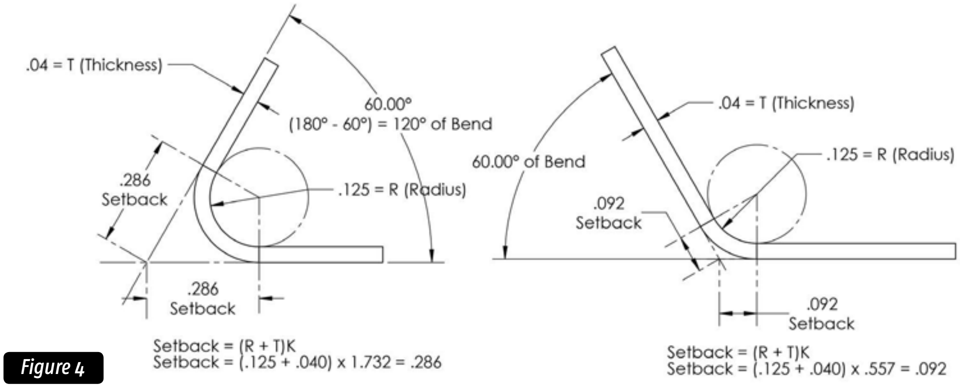


Figure 4

Deg.	K	Deg.	K	Deg.	K	Deg.	K	Deg:	K
1	0.0087	37	0.3346	73	0.7399	109	1.401	145	3.171
2	0.0174	38	0.3443	74	0.7535	110	1,428	146	3.270
3	0.0261	39	0.3541	75	0.7673	111	1.455	147	3.375
4	0.0349	40	0.3639	76	0.7812	112	1.482	148	3.487
5	0.0436	41	0.3738	77	0.7954	113	1.510	149	3.605
6	0.0524	42	0.3838	78	0.8097	114	1.539	150	3.732
7	0.0611	43	0.3939	79	0.8243	115	1.569	151	3.866
8	0.0699	44	0.4040	80	0.8391	116	1.600	152	4.010
9	0.0787	45	0.4142	81	0.8540	117	1.631	153	4.165
10	0.0874	46	0.4244	82	0.8692	118	1.664	154	4.331
11	0.0963	47	0.4348	83	0.8847	119	1.697	155	4.510
12	0.1051	48	0.4452	84	0.9004	120	1.732	156	4.704
13	0.1139	49	0.4557	85	0.9163	121	1.767	157	4.915
14	0.1228	50	0.4663	86	0.9324	122	1.804	158	5.144
15	0.1316	51	0.4769	87	0.9489	123	1.841	159	5.399
16	0.1405	52	0.4877	88	0.9656	124	1.880	160	5.671
17	0.1494	53	0.4985	89	0.9827	125	1.921	161	5.975
18	0.1583	54	0.5095	90	1.000	126	1.962	162	6.313
19	0.1673	55	0.5205	91	1.017	127	2.005	163	6.691
20	0.1763	56	0.5317	92	1.035	128	2.050	164	7.115
21	0.1853	57	0.5429	93	1.053	129	2.096	165	7.595
22	0.1943	58	0.5543	94	1.072	130	2.144	166	8.144
23	0.2034	59	0.5657	95	1.091	131	2.194	167	8.776
24	0.2125	60	0.5773	96	1.110	132	2.246	168	9.514
25	0.2216	61	0.5890	97	1-130	133	2.299	169	10.38
26	0.2308	62	0.6008	98	1.150	134	2.355	170	11.43
27	0.2400	63	0.6128	99	1.170	135	2.414	171	12.70
28	0.2493	64	0.6248	100	1.191	136	2.475	172	14.30
29	0.2586	65	0.6370	101	1.213	137	2.538	173	16.35
30	0.2679	66	0.6494	102	1.234	138	2.605	174	19.08
31	0.2773	67	0.6618	103	1.257	139	2.674	175	22.90
32	0.2867	68	0.6745	104	1.279	140	2.747	176	26.63
33	0.2962	69	0.6872	105	1.303	141	2.823	177	38.18
34	0.3057	70	0.7002	106	1.327	142	2.904	178	57.29
35	0.3153	71	0.7132	107	1.351	143	2.988	179	114.59
36	0.3249	72	0.7265	108	1.376	144	3.077	180	Inf.

Figure 5

into the calculations necessary for bends that are more acute or obtuse. (Figure 4) We still use setback, which is radius plus thickness; however, this time we multiply a K-factor. A K-factor chart is available in AC 43.13-1B (Figure 5). This is simply another complex mathematical calculation distilled into a matrix that correlates the correction factor to the angle of the bend. To calculate the length of each flat, use the same procedures as we used in calculating for a 90-degree bend. Simply take the given dimension and subtract the setback. When calculating the bend allowance for the bends that are other than 90 degrees, simply multiply the bend allowance for 1 degree times the number of degrees that the metal is bent. This is the same number of degrees used when calculating setback using K-factor.

You may have become very proficient at bending aluminum using the old standby method where you start with an extra-large sheet, bend it to the appropriate angle, then cut off the excess material to come up with your final dimension. There's nothing particularly wrong with using this method, but if you have more than one bend you're going to be in big trouble. This is where I see individuals getting fairly creative by guessing at the dimensions, bending the metal, and re-measuring to see how far off they are. Then they change their original dimensions by the amount of error in the original part and re-bending a new piece. After about three or four tries, they can typically get pretty close. But as you might imagine, this can be quite time-consuming, expensive, and frustrating. If you find yourself working on aluminum aircraft on a regular basis, the amount of effort required to learn to do sheet metal lay-out is really quite minimal. Once you've practiced a bit, you can develop confidence and accuracy worthy of a professional. It's very rewarding to go through the process of laying out a fairly complex part with multiple bends and have it fit into the aircraft on the first shot. In part two of this article, we will address some of the more practical aspects of bending aluminum such as how to place the metal into and set up the sheet metal brake, establishing a sight line, and some other tips and tricks that will get you on your way to becoming a sheet metal whiz. *EAA*

Carol and Brian Carpenter, EAA 678959 and 299858, owners of Rainbow Aviation Services, have co-authored two aviation books and team teach the Light Sport Repairman Workshops. Brian is a CFII, DAR, A&P/IA, and the designer of the EMG-6 (an electric motorglider). Carol is an SPI, PP, LSRM, and FAAST representative.

Jonathan Arney and his Kolb off to find the sea breeze calm.

Sea Breeze

The Search for calm air

BY JONATHAN ARNEY, PH.D. WITH STEPHEN JESSUP, PH.D.

ON A WARM SUMMER DAY, I like nothing more than a trip to my local airport for a relaxing flight in my E-LSA Kolb. On a typical June day, I check the weather and see the wind is mostly out of the southwest at 7 knots. The local windsock is showing wind from the southwest but is swinging around plus or minus 45 degrees. This is a very good indication of strong thermal activity and a promise of a bumpy flight. The sky is perfectly clear, so I make a "go" decision. A few pulls on the starter gets my 447 Rotax going. I back-taxi to the end of the turf runway and go through a CIGAR checklist. With the gauges in the green, I swing around into the wind and ease the throttle to full open. The tail comes up quickly, and I take off. When I reach a couple hundred feet, I'm hit by a sudden bump of turbulence. Nothing dangerous, but I do have to lean on the stick to keep the wings level. The thermals persist and make for a turbulent flight. I know my glider colleagues are enjoying the free lift from the thermals, but my intent is to find turbulence-free air and do a relaxed bit of flying. The calm air I am searching for on this flight is called a "sea breeze calm" and is found along many lakes and rivers, and especially along ocean shorelines.

THE SEA BREEZE ENGINE

I am fortunate to live about 5 miles south of Lake Ontario where a sea breeze (or lake effect breeze as it is also known) is a common occurrence. A sea breeze is a simple heat engine driven by the sun's energy. The sun warms the land and forms those pesky thermals most of us love to avoid. As shown in Figure 1, the warm, rising air of the thermals moves out over the water where it cools, and then sinks over the water. (No wonder glider pilots don't like to fly over lakes!) This cool air then completes the circulation by moving onto shore as a sea or lake breeze. At first glance, Figure 2 seems to suggest that flying over land will be turbulent, and flying offshore will be smooth. But often the sea breeze pushes a considerable distance inland, bringing cool, extremely smooth air with it.

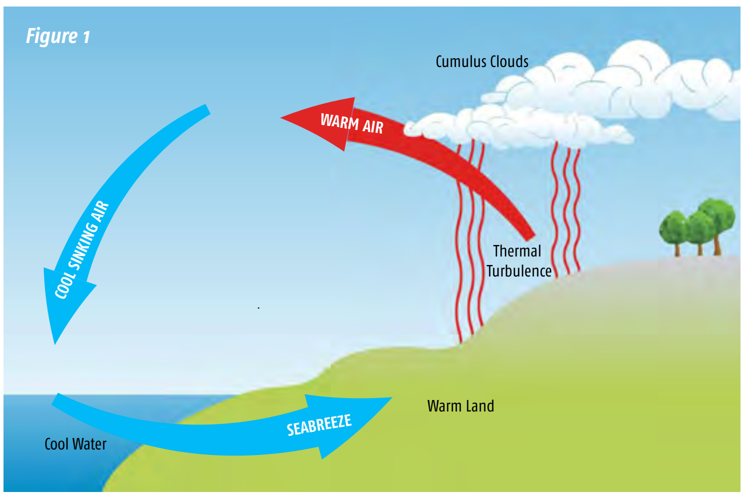
The onshore breeze of cool, calm air meets the warm air on shore to form a micro-cold front, as shown in Figure 2. Like most cold fronts, there is a difference in the wind direction on the two sides of the front. On this day, the prevailing wind is from the southwest, but the sea breeze is from the north. The winds are blowing, but the location of the cold front is nearly stationary. A sea breeze front can last for most of a day and provide a stationary corridor of smooth air, as shown in Figure 2, all along the shore. This is a region of extremely smooth air and is a joy to fly in. As an ultralight or light-sport pilot, what you want to know about the sea breeze calm is when it is likely to form; how to locate the front; and the approximate dimensions of the calm corridor, d_i and d_a.

PHOTOGRAPHY COURTESY OF **JONATHAN ARNEY**

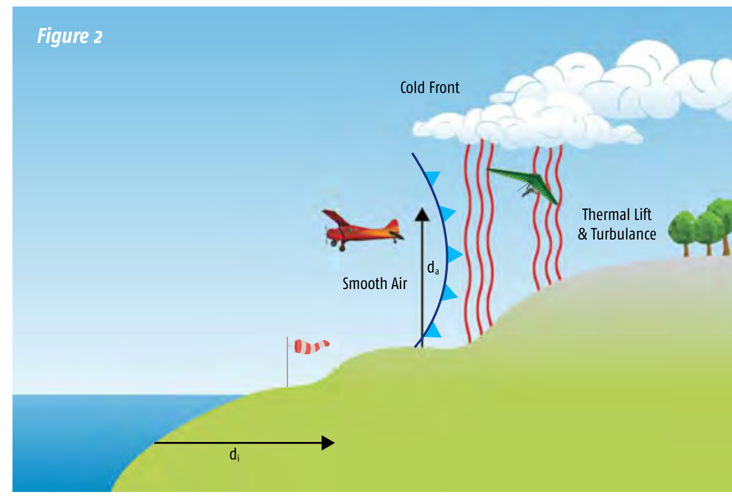
WHEN THE COLD FRONT FORMS

Sea breeze cold fronts occur almost anytime the sun is shining, particularly in spring and summer, and the prevailing winds are less than 10 knots. In other words, when the conditions are best for ultralight and light sport flying! The meterological condition for a lake effect breeze on the Great Lakes is $U^2/(T_w - T_{air}) < 5$, where U is the surface wind speed in meters per second, T_w is water temperature, and T_{air} is air temperature in degrees Celsius.

The size of the body of water also matters. Oceans work well, as do the Great Lakes, but many small lakes and wide rivers can also produce a sea breeze effect. In western New York, for example, I have found that the Finger Lakes can generate these zones of smooth air along their shores.



The sea breeze engine driven by onshore thermals. Left is north and right is south in this illustration.



The sea breeze cold front. North is to the left, and south is to the right.

ILLUSTRATIONS BY **BRANDON JACOBS**

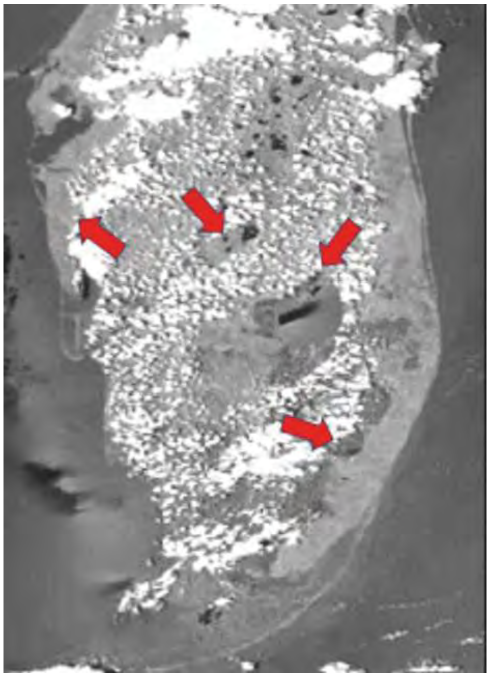


Figure 3: *Satellite image of southern Florida. Red arrows show the edges of sea and lake effects. Even small lakes show the effect.*

Even some large rivers can support the effect. The size of the body of water influences the strength, size, and frequency of the sea breeze effect, so it isn't essential to live near large bodies of water to find a sea breeze effect. Indeed, hunting for the effect over lakes and wide rivers makes an interesting flying adventure.

HOW TO FIND THE SEA BREEZE COLD FRONT

The easiest way to locate a sea breeze cold front is to start a few miles away from the edge of the water and fly toward it. A good altitude to fly is anywhere between 500 and 1,500 feet AGL. If the sea breeze front is present, the thermal turbulence will suddenly disappear at some distance from the shore, indicating that you have passed through the cold front. At this point, you can turn parallel to the shoreline and follow it as far as it goes. I often take advantage of these sea breeze calms along Lake Ontario for a comfortable cross-country trip along the shore.

Another way to locate a sea breeze cold front is to look for a line of clouds parallel to the shore. These cloud edges don't always form when a good sea breeze front is present, but if the clouds are present, it is easy to see where the front is located. Figure 3 shows a satellite view of a strong sea breeze front around the Florida peninsula, and Figure 4 shows the line of clouds along the shore of Lake Ontario.

SIZE OF THE INLAND CALM

The distance, d_i in Figure 2, between the shoreline and the sea breeze cold front can be anything from zero (directly at the shoreline) to several miles inland. Figure 4 shows a particularly strong sea breeze with the front distance, d_i, around 5 miles inland. If the prevailing wind is from offshore, then the sea breeze will be farther inland. Or the prevailing wind could be parallel to the shore with a corresponding shorter d_i, and if the prevailing wind is from the land, there is still generally a sea

ILLUSTRATIONS COURTESY OF **JONATHAN ARNEY**

Figure 4: *Sea breeze clouds along the shore of Lake Ontario, New York.*

breeze with a much shorter d_i. In my experience searching for sea breezes and smooth air, if the prevailing wind is slow enough for me to be comfortable flying my Kolb, then conditions are almost always favorable for a sea breeze cold front with d_i between zero and 3 miles.

The altitude, d_a, of the front can be estimated from the behavior of the thermals. If the thermals top out into clouds, they will mark the top of the sea breeze engine. In the absence of thermal clouds, the top of the engine can be estimated from the temperature-dew point spread and average temperature lapse rate. This suggests the sea breeze engine will generally be at a comfortable VFR altitude below the cloud base. Indeed, if the thermals are building significantly beyond a comfortable sea breeze effect, it is time to worry about the formation of storms. But given that these more severe weather conditions are not the ones I fly in, I can expect a good lake effect calm to be available almost any time I'm comfortable flying my Kolb. And going hunting for them, even at smaller lakes, can provide an entertaining experience and a greater appreciation of the workings of our atmosphere. *EAA*

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Steve Jessup, Ph.D, is assistant professor of meteorology at The College at Brockport State University of New York. He specializes in severe weather, flash flooding, and the intersection between these two types of events.

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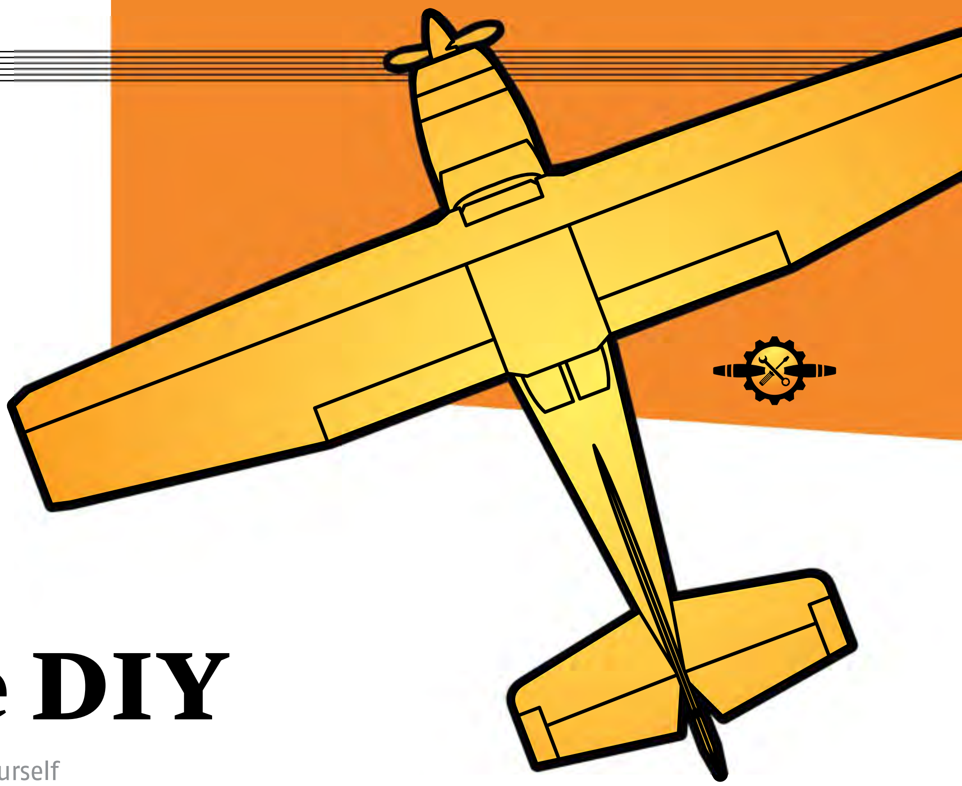

Ultimate DIY

Designing it (homebuilt airplane) yourself

BY BUDD DAVISSON

THERE IS SOMETHING about someone striking out on their own to design and build an airplane that exists only in their imagination that is heroic. Recently, a friend started sending me images he has collected from Facebook of a variety of 1960s fly-ins, and an unexpected number of the aircraft featured were one-off, I-did-it-all-myself airplanes. Because of the proliferation of kits and available plans, we don't see that as much as we used to. However, when we do, they are often off-the-wall, amazingly complicated projects. The John Bally 1/3-scale B-17 and the 55 percent Jim O'Hara P-38 come to mind. Incredible efforts! And only those who have attempted projects like that can begin to understand the determination involved.

DIY AIN'T EASY

In what seems like another life, my buddy Jim Clevenger and I found ourselves sucked into building airplanes for which no plans exist. Specifically, we designed and built full size, flying replicas of the early 1930s Wedell-Williams Model 44 racers. The 44 was the first land-based airplane to break 300 mph, officially going 305.3 mph in 1934. Ours weren't that fast. Or at least we didn't push them that hard, but speed was unimportant. What was important was that we started with nothing and had to solve about a bazillion problems all at once, every step of the way. And these were simple rag-and-tube airplanes. I can't imagine all of the research and work Bally and O'Hara put into their airplanes: multiengine and all metal, with every person on the planet knowing the airplanes so well that any deviation from the original would be seen immediately.

Designing and building a homebuilt airplane, no matter how simple, is not for the faint of heart. Nor is it for someone who doesn't have total respect for the laws of physics and at least a reasonable understanding of both structural and aerodynamic design.

A basic tenet of aircraft design is the absolute understanding that an airplane is really nothing more than a failure-prone machine that gets you high enough to bust your tushie. In other words, gravity always wins. Whether it is the simplest ultralight or a 450-hp barn-burner like our Wedells, gravity is always lurking around eager to take advantage of any one of three different kinds of mistakes: piloting skill, aerodynamic faults, and structural weaknesses. Any of them going wrong can compromise the other two and lead to disaster. That's the bad news. The good news is that throughout the history of aviation, thousands of folks have successfully gone from daydream to day-tripping in an airplane that is uniquely theirs and no one else's. But, there is a process involved, and only part of it happens in the workshop.

If doing a replica, full scale or not, the first step is almost as laborious as the construction: researching the design so that you know far more about it than the owners do. Then, it's critical to find lots of photos and drawings of it. If coming up with a new design that is uniquely yours, this first phase is simplified, but don't expect the first design put on paper to be the one you build. You'll change your mind dozens of times.

Incidentally, here's a caveat that must be kept in mind: Except in rare cases, the resale value of self-designed airplanes is very, very low. If embarking on this route, do it simply because you want to do it and do so knowing full well that a sale will barely cover the cost of materials and probably not even that.

GETTING STARTED

Whether replicating a design or initiating a new one, there are specific procedures involved. Most are obvious and, within certain limitations, easy enough to follow that one doesn't really need an engineering degree to do what needs to be done. However, even an engineer (like me), brings in a set of outside eyes to review what is being done. Just as we bring in a technical counselor to review our handiwork, when building we need a professional to look over our shoulders when designing widgets and crunching numbers.

Some of the very best news is that among EAA and its members, the sources of design information and educational material available on the web has been expanding exponentially.

Loosely, the procedures (most of the information for them can be Googled) include but are definitely not limited to:

- **Quantify the mission:**
  How many people, what kinds of speed and range, *g*-loads required, etc.

- **Apply the mission requirements:**
  The above will dictate size, weight, and structural allowables to be used in calculations.

- **Thumbnail the aerodynamics:**
  There are some basic rules of thumb regarding just about everything about the aerodynamics, which will loosely define the size and shape of the airplane. These include wing loading desired (gives you the wing area for the weight), aspect ratio/span loading (gives approximate span, affects speed and altitude/climb performance), power-to-weight ratio (determines climb and engine size for performance required, which also drives fuel onboard, which affects weight, *g*-tolerance, structure, etc.). Look at comparable certified airplanes and see what their weights, wing loadings, power-to-weight ratios, control surface moments and volumes, etc. are and make your decisions based on that. Stay within established parameters. Don't expect to fly a 24-pounds-per-square-foot, 4:1 aspect ratio wing on 65 hp and clear a gopher standing on the end of the runway. Not even a short one.

- **Select the airfoil:**
  Don't get overly complex in this area. Fewer than eight or 10 commonly used airfoils bridge just about any use most pilots can imagine. The pros and cons of each of those airfoils can be found online with the performance characteristics desired explained. Do not think you know more about airfoils than the pros do. Don't modify one.

- **Select the material:**
  Rag and tube is the easiest structure to design and build and is the most forgiving. Aluminum requires much more attention to detail because you have to be constantly aware of the way the stress flows from one part to another with no concentrations. It is also more demanding when designing/building fittings, frames, etc. Composites may be as forgiving as rag and tube, but only if the design is well done; however, composites involve the time-consuming process of developing molds unless you're doing glass-over-foam moldless construction like a VariEze. There is much less design information for composites than the rest. Wood is similar to aluminum in terms of detail design but has the highest parts count of all of them.

Some of the very best news is that among EAA and its members, the sources of design information and educational material available on the web has been expanding exponentially.

- **Structural analysis:**
There are lots of thumbnail formulas that will get your material selections in the ball park, but personally, I'd rather not see a nonengineer doing that, although I know lots do. Remember that gravity thing? And the sudden stops it can orchestrate? I would vote for designing your structure using whatever input you can find, including looking at other aircraft to see how it was done there. Then I would take the drawings to a pro and pay what is required to have him check what you have done and run some numbers on it. This reminds me of a well-known, one-off homebuilt that was designed to go fast. The builders were all very experienced but eyeballed most of the engineering. It was to be exhibited overseas, and the show sponsors demanded that an analysis be done. When the professionals were finished, it turned out that the spars were only good for about 3*g*. So much for eyeball engineering!

- **Drawings:**
Computers are your friend — do not discount the incredible advantage a computer gives to the newbie airplane designer. When it comes to structural analysis, it is possible to do it on an Excel financial spreadsheet, but reread the last paragraph and use a pro. However, when it comes to doing the drawings, unless you're a Rapidograph and vellum guy like me, it's worth the time to learn a CAD program like SOLIDWORKS, which is available free to EAA members. One of the cool things they can be used for is actually printing out joints and fittings full size and using the prints as patterns. However, be advised that most paper won't hold a precise dimension because of humidity. So, if you print them yourself, always check the print against the known dimensions. Having a commercial printing outfit print them out on stabilized paper eliminates that problem and lets you work with larger, full-sized sheets.

- **Mock-ups save headaches:**
When designing the fuselage for another golden age racer, I built a mock-up of the cockpit and discovered something I didn't know: when you pull the stick back on any airplane, your elbow translates outward almost 2 inches. In this case that meant that with the fuselage being so narrow, one of the diagonals would trap my elbow and limit movement. It's amazing that, when we mock something up, we discover things in so many areas that we hadn't expected.

So, if your dream airplane is still a dream but lives only in the theater of your mind, don't be afraid of stepping over the line and living that dream. That's what EAA is all about. *EAA*

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

Bench Top Paint Booth

BY JEFF SEABORN, EAA 793688; FOOTHILLS, ALBERTA, CANADA

I FOUND THAT PROJECTS of mine, whether it's building aircraft or restoring cars, require the occasional use of "rattle can" spray paint.

To minimize the overspray in my shop, I created this inexpensive paint booth. It is simply a large plastic container on its side with a bathroom fan pulling the overspray through a cheap disposable furnace filter.

I chose a semitransparent container so the item being painted has a lot of light on it, which makes it easier to see the coverage. The fan is a cheap bathroom fan that interestingly had a plug-in built into it already; it simply plugs into an extension cord. I had to relocate the plug and install a rubber grommet to protect the wires.

Cutting a hole in the bottom of the container, I riveted some scrap aluminum as brackets and doublers to mount the fan. The furnace filter fits into the bottom of the container with some foam pipe wrap around the filter's perimeter. This provides a snug fit, sealing the edges of the filter while securing it in place.

I think the photos likely speak for themselves. In all, the cost came to about CA$30 (about $23).

This does not protect a person from the fumes, but it certainly does a wonderful job capturing most, if not all, of the overspray.

Power Paint Mixer

BY TRACY BUTTLES, EAA AIRCRAFT MAINTENANCE TECHNICIAN

WHEN USING AIRCRAFT COVERING products, I had noticed that the liquid would settle on the bottom of the can and require a lot of time to stir by hand. Not having a professional-style paint shaker, I made up this power paint mixer from parts in the shop. I cut a plastic auto body Bondo spreader in half and riveted those pieces back to back on a wood dowel. Using an air drill (no sparking) and keeping the mixer below fluid level, it did not take long to stir up the product and get it ready for use.



Clamp Storage Rack

BY CHARLIE BECKER, EAA DIRECTOR OF CHAPTERS, COMMUNITIES, AND HOMEBUILT COMMUNITY MANAGER

YOU CAN NEVER have too many clamps when building an airplane. The issue is how to keep them handy but out of your way. Here is a solution that might help you. I simply took a length of conduit and bored some 3/4-inch holes about halfway through some scrap 2-by-4s. Find a sturdy place to mount the assembly with some construction screws. The nice part about this design is you can make it as long as you want by just adding some 2-by-2 supports. This clamp rack has worked great, and the cost is minimal. *EAA*

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EAA Visa	42	www.eaa.org/visa	800/564-6322
EAA Webinars	24	www.eaa.org/webinars	800/967-5746
EAA Women Soar-You Soar	106	www.eaa.org/womensoar	920-426-6859
EAA WomenVenture 2017	108	www.eaa.org/womenventure	920-426-6859
EAA Young Eagles	109, 116	www.youngeagles.org	877/806-8902
EAA Young Eagles Raffle	107	http://www.eaa.org/Yeraffle	800/236-1025
Evolution Aircraft Company	43	www.evolutionaircraft.com	541/923-2233
Ford Motor Company	51	www.ford.com	800/392-3673
Garmin	7	www.garmin.com/ADS-B	800/800-1020
GRT Avionics	24	www.grtavionics.com	616/245-7700
Hilton Head Island Motoring Festival	122	www.hhimotoringfestival.com	843/785-7469 X4
HTP America Inc	105	www.usaweld.com	800/872-9353
J.P. Instruments	31	www.jpinstruments.com	800/345-4574
John Deere	IBC	www.johndeere.com/gator	309/765-8000
Lancair International	29	www.lancair.com	866/526-2247
Leading Edge Air Foils, LLC	124	www.leadingedgeairfoils.com	800/532-3462
Lockwood AV Supply/Rotax Srvc Cntr	42	www.lockwood.aero	800/527-6829
Lycoming	21	www.lycoming.com	800/258-3279
MT-Propeller	124	www.mt-propeller.com	386/736-7762
MyWrightFlyer	101	www.mywrightflyer.com	
Poly-Fiber Aircraft Coatings	3	www.polyfiber.com	800/362-3490
Randolph Aircraft Products	33	www.randolphaircraft.com	800/362-3490
Remos	33	www.remos.com	49-3973-225519-0
Rotorway	49	www.rotorway.com	480-961-1001
Sigtronics Corporation	105	www.sigtronics.com	909/305-9399
Sky-Tec/Hartzell Engine Technologies	25	www.skytecair.com	800/476-7896
Sonex Aircraft, LLC	113	www.sonexaircraft.com	920/231-8297
Sporty's Pilot Shop	27	www.sportys.com/stratus	800/SPORTYS
Stemme USA	35	www.stemme.com	803/726-8884
Superflite	112	www.superflite.com	800/323-0611
Superior Air Parts	37	www.superiorairparts.com	800/277-5168
Tempest	2	www.tempestplus.com	800/822-3200
Trade-A-Plane	113	www.trade-a-plane.com	800/337-5263
Trutrak Flight Systems/AFS	38	www.trutrakap.com	866/TRUTRAK
Van's Aircraft, Inc.	19	www.vansaircraft.com	503/678-6545
Wag-Aero	121	www.wagaero.com	800/558-6868

Mk. II Astro Compass

THE ASTROCOMPASS FIRST CAME into use in the early 1930s, primarily to allow aerial navigation in the polar regions where magnetic compasses are notoriously unreliable due to the Earth's magnetic field being nearly vertical. Gyrocompasses — not to be confused with a directional gyro/heading indicator — were and are not a viable alternative in the polar regions either because the Earth's rotation makes them unstable. When pointed at a known star, an astrocompass will indicate true north. Various manufacturers produced the Mk. II Astro Compass pictured here, which was used predominantly in Royal Air Force and Royal Canadian Air Force aircraft during World War II. Some were known to be used in American aircraft as well. EAA

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