September 2014
Volume XLV
Number 9

The consumer resource for pilots and aircraft owners

The Aviation Consumer®

Waco Great Lakes

It's fully aerobatic, well built and has vintage charm… page 11

Bug Cleaners Page 19

AoA systems… page 4

POV Action Cameras … page 14

R44 Helicopters… page 24

The Aviation Consumer

EDITOR
Larry Anglisano

SENIOR EDITOR
Rick Durden

EDITORIAL DIRECTOR
Paul Bertorelli

CONTRIBUTING EDITOR
Jonathan Doolittle

SUBSCRIPTION DEPARTMENT
P.O. Box 8535
Big Sandy, TX 75755-8535
800-829-9081
www.aviationconsumer.com/cs

FOR CANADA
Subscription Services
Box 7820 STN Main
London, ON 5W1
Canada

Back Issues, Used Aircraft Guides
203-857-3100

REPRINTS: *Aviation Consumer* can provide you or your organization with reprints. Minimum order is 1000 copies. Contact Jennifer Jimolka, 203-857-3144

AVIATION CONSUMER (ISSN #0147-9911) is published monthly by Belvoir Aviation Group LLC, an affiliate of Belvoir Media Group, 800 Connecticut Avenue, Norwalk, CT 06854-1631. Robert Englander, Chairman and CEO; Timothy H. Cole, Executive Vice President, Editorial Director; Philip L. Penny, Chief Operating Officer; Greg King, Executive Vice President, Marketing Director; Ron Goldberg, Chief Financial Officer; Tom Canfield, Vice President, Circulation.

Periodicals postage paid at Norwalk, CT, and at additional mailing offices. Revenue Canada GST Account #128044658. Subscriptions: $84 annually; single copies, $10.00. Bulk rate subscriptions for organizations are available.

Postmaster: Send address corrections to AVIATION CONSUMER, P.O. Box 8535, Big Sandy, TX 75755-8535. In Canada, P.O. Box 39 Norwich, ON NOJ1PO, Canada. Publishing Agreement Number #40016479

YELLOWBIRD: AFFORDABILITY REIMAGINED

Walking around AirVenture 2014 at Oshkosh—almost 30 years from the day that I took my first training flight in a Cessna 150—my 15-year-old daughter Ashley spotted AOPA's Yellowbird 152 on display. "Dad, I need one of these," she matter-of-factly remarked in a voice that commanded the same attention as her mother's. I was 15 when I first enthusiastically strapped into the little trainer and now Ashley is focused on dual instruction of her own in a 152. A bright yellow one, she says. While it's tough to find anyone that's not fond of the 150/152 ("The J3 of our generation," says AOPA president Mark Baker), let's put emotion aside.

If you haven't heard about the Reimagined 152 and 150 (and many folks that I talked with at the show haven't) these are completely refurbished airplanes that AOPA purchased from Aviat Aircraft, the folks that manufacture the Husky, Eagle and the Pitts.

Although it has no intention of getting into the aircraft refurb business, AOPA's Baker said the three purchased Yellowbirds are intended to introduce and in many cases reintroduce a means to affordable flying. How affordable? AOPA estimates the hourly cost of the refurbed trainer to be around $63. While that's roughly half of what I've paid per hour for a well-worn Warrior at the local flight school, that number could be optimistic. What's also optimistic is hoping that buyers—and that might include flying clubs, flight schools and individuals—will pay upwards of $90,000 for one. While cheaper than many new LSA models (and more than many Skyhawks), the Yellowbird that I saw on display was pretty stark in comparison to an average LSA.

Despite prices that might top $130,000, many buyers are attracted to new LSAs because of modern avionics and accessories, but in the Yellowbird, there's no Dynon or Garmin G3X Touch gee-whiz glass because this isn't an LSA. The retrofit avionics have to conform to the original type certificate or have an STC. Instead, the Yellowbird that I saw had a Garmin aera GPS, digital navcomm, transponder and iron gyros. While that's plenty for a primary trainer—and represents the simplicity of what the 152 stands for—I think buyers will demand more from an aircraft with a $90,000 price tag.

On the other hand, I'm all for like-new refurbishment and I think one that's been thoroughly refurbished by a well-known aircraft company deserves a premium price tag. Baker isn't sure if the Reimagined 152 has legs, but I give AOPA credit for giving the venerable 152 another try. And kudos to my young, but sharp, daughter for recognizing a good trainer when she sees one. Really, how much is that yellow 152 going to cost me per hour?

HERE COME THE ELECTRICS

Speaking of little yellow airplanes, also on display at AirVenture was the PC-Aero Sun Flyer proof-of-concept solar electric trainer. The single-place airplane (a two-place model is planned) has two electric motors on a common shaft and develops a measly 40 HP, but a single failure results in only a 50 percent deficit in total power. Moreover, the company says motors can last as long as 20,000 hours and are powered by a battery pack, plus solar panels that are mounted on the wings. Endurance is shy of three hours of flight time and the aircraft can cruise at roughly 80 knots. Park the aircraft outdoors for three days and the solar panels will completely charge the battery. Regular charging takes about six hours and batteries can be as much as $15,000 each.

Certified as an LSA, the Sun Flyer is targeted to cost under $200,000 and have direct hourly operating costs in the $5 to $10 range. We'll be following the Sun Flyer and the emerging electric market closely. —*Larry Anglisano*

LIGHTSPEED PFX NITS

Your article about the Lightspeed PFX ANR headset in the August 2014 issue of *Aviation Consumer* could not have arrived at a more opportune time and was spot on in its evaluation.

I had just purchased the Zulu PFX a few days earlier and while I think it is the quietest and most comfortable headset on the market, some of the same bizarre effects that you noticed—low-pitched fluttering and ANR performance issues when moving the head—were present in mine as well. I have serial number 189.

I did reach out to Lightspeed and they thought it may have been a fitting issue. The company immediately sent out new earseals and a larger headpiece cushion. I changed both of these and noticed that the ill effects lessened considerably.

However, something I discovered is that if you activate Bluetooth while the headset is on, the automatic headset shutdown feature is disabled. When I inquired to Lightspeed about this issue, they indicated that the CPU still hears noise and keeps the headset on. This is extremely frustrating because when you go to use your headset the next time, the batteries will likely be spent. I'm hoping that a firmware update is in the works to correct this.

Andrew Elwood
Essex, Connecticut

We've gotten mixed reviews from new PFX owners, including one that had two new sets fail out of the box. As we report in the PFX follow-up on page 23 of this issue, swapping the headband pad to the taller one cured the ANR problems we experienced during the evaluation. As for the other issues, Lightspeed said it's working on several improvements for a future firmware upgrade.

INLET AIR FILTERS

To add more information to your recent air filter comparison article (August 2014 *Aviation Consumer*), I compared the Brackett air filter to the Donaldson air filter on my Beech P-35 Bonanza, equipped with a Continental IO-470N. The data was recorded using a JPI EDM 800 and a Horizon digital tach. Each test was at full throttle and the tests were performed on the same day to make the conditions between tests as similar as I could. Pressure altitude was 9500 feet and the temperature was 66 degrees.

With the Brackett installed, I recorded fuel flow at 13.4 GPH, manifold pressure was 20.6 inches and the measured RPM was 2450. With the Donaldson, manifold pressure increased to 20.7 inches and I gained 2 MPH in both indicated and true airspeed.

I have the engine oil analyzed each time I change the oil and the oil filter after 45 to 50 hours of use. I saw no difference in the silicon readings between the air filters, so I presume the Donaldson and Brackett air filters do an equal job of filtering the engine air.

While there was a slight increase in performance with the Donaldson over the Brackett air filter, I found the Brackett element was much easier than the Donaldson air filter to remove, clean and reinstall. Also, the Brackett foam element is less costly than the Donaldson air filter assembly.

After using the Donaldson filter for 472 hours, I switched back to the Brackett. For me, the very slight increase in performance of the Donaldson filter did not justify the extra time in maintenance or cost over the Brackett.

Rick Grossmann
Overland Park, Kansas

Excellent air filter comparison in your August issue. You guys did all you could possibly do without getting into expensive lab testing, but in my opinion (as an experienced A&P with an IA certificate) that doesn't matter much. What does matter is that the filter is serviced on a regular basis. To me, it's less about questionable performance gains and more about maintaining air flow to the engine.

Stan Sutton, Jr.
via email

CABIN COOLERS

Nice article on portable cabin coolers in your August issue, but you missed an important factor. I bought an Arctic Air Cooler about six years ago. The perceived benefit provided by any of these coolers is greatly affected by the dewpoint. An 85-degree cabin with a 75-degree dewpoint will be significantly more unpleasant compared with the dewpoint at say 60 degrees.

Sure the cooler cools, but it also dehumidifies the cabin air. I found my cooler most effective when running it from the time the cabin door closes until just after liftoff and then again just after touchdown until the cabin door opens.

Ted Stanley
via email

CONTACT US

Editorial Office
860-614-1987
E-mail: consumereditor@hotmail.com

Subscription Department
P.O. Box 8535
Big Sandy, TX 75755-8535
800-829-9081

Online Customer Service:
www.aviationconsumer.com/cs

Back Issues, Used Aircraft Guides:
203-857-3100
E-mail: customer_service@belvoir.com

For weekly aviation news updates, see www.avweb.com

Angle of Attack Systems: A Growing Market

As the FAA eases the installation approval process, the AoA market has more options. We like Safe Flight's leading edge sensor and Garmin's air/data system.

by Larry Anglisano

For years the FAA snubbed its nose at angle of attack system retrofits for certified light aircraft. A handful of owners got lucky when the shop was able to sneak field approval paperwork through the FSDO, while others ran into a regulatory roadblock when field inspectors deemed AOA retrofits too major of a modification to approve. The expensive and time-consuming chase for additional supporting data often put an end to the project. That's changing.

Under a new policy, manufacturers must build the systems according to standards from the American Society for Testing and Materials (ASTM) and apply for FAA approval for the design via a letter certifying that the equipment meets ASTM F3011 standards. That makes it easier for shops to win installation approval and easier yet for manufacturers to market a new breed of AOA systems to an industry that's recognized the AoA indicator as a useful tool for avoiding aerodynamic stalls.

CHECKLIST

- New regulatory guidelines are streamlining AOA approval process.
- Prices for most AoA systems are affordable—under $2000 for most.
- Sensor location and initial calibration is critical to performance.

AOA 101

In case you were absent on the first day of private pilot ground school, angle of attack is the acute angle between the chord line of the airfoil and the direction of the relative wind. Exceed the critical angle of attack and the airfoil stalls. The key is to know how much remaining lift is available to keep the airfoil flying. That's where angle of attack and lift reserve systems come in. But there are differences among them.

A lift reserve computer uses the difference in pressure measured between two ports on a pitot probe that is calibrated and used to determine the lift reserve. The trouble with that is the pressure differential may change with density altitude, flap configuration, G-loading and even with changes in aircraft weight. This means the system may be calibrated (a critical step in the installation process) during conditions that won't always remain constant.

Normalized angle of attack systems, on the other hand, are designed to provide consistent AoA indications that are not related to atmospheric conditions and the aircraft configuration, including loading.

BENDIX KING KLR10

Made for Bendix King by Alpha Systems, the KLR10 lift reserve system

The Alpha Systems pressure probe, lower photo, mounts to an existing inspection plate. The Alpha probe and pressure serializer is used in the Bendix King KLR10 system.

Angle-of-attack indicators are best positioned on top of the glareshield, within your field of vision when looking out the windshield. Safe Flight Instrument's SCx, top photo, uses an adjustable indexer to change the reference AoA. The Advanced Flight Systems AoA Pro can overlay on EFIS displays or use a dedicated indexer, lower pictures.

references an air pressure probe that mounts on an existing inspection plate on the underside of the wing.

Installation is straightforward as long as the probe is installed outside of the propeller arc, in undisturbed air and placed between 10 to 90 percent of the wing's main aerodynamic chord.

The probe connects to an interface module that serializes the differential pressure and then sends the data to a glareshield-mounted AoA indicator. The indicator is available with an optional swivel mount so you can mount it to a curved glareshield or adjust it for more precise positioning within your primary field of vision.

The system can be connected to the aircraft audio panel for audible voice alerts. As the system senses angle of attack, the first warning is to "check AOA," with a red caution alert on the display. An increasing angle of attack triggers a "caution, too slow" callout, while the display flashes red. As the wing enters an aerodynamic stall, the voice alert calls "too slow, too slow," while the display flashes a down arrow prompting you to push the nose down.

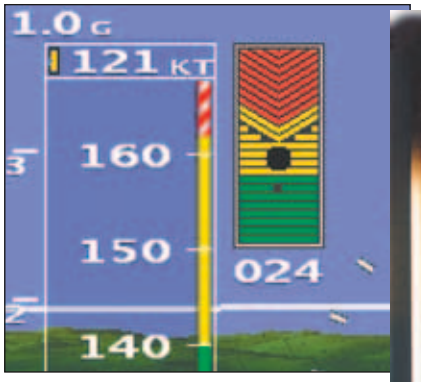
Calibrating the system is critical to performanc. There are three main reference calibrations that need to be performed after installation, including one at zero airspeed, one at cruise alpha and another at a high angle of attack.

ALPHA SYSTEMS

Alpha Systems is the clear leader when it comes to the variety of available display options. As noted in the Bendix King KLR10 section, the system uses an inspection plate-mounted pressure probe (available in a heated version) and a remote serializer. The company recently added a HUD (heads up display) adapter for use with its rectangular indicators.

And when it comes to indicators, take your pick, but get ready to be overwhelmed in the process. Simplifying the choice, each different display option is sold in a kit.

There's the Griffin display, which presents AoA in a simple chevron and a so-called "donut" that indicates an on-speed condition. Come in with too low of an angle of attack, the yellow chevron will light up, telling you to put the nose up. Should you come in with too high of an angle of attack, the red chevron will light up, warning you to lower the nose.



The Falcon is a light-bar-style display with a blue LED that represents an on-speed condition. The bar display turns yellow when the AoA gets too low and red when it gets too high.

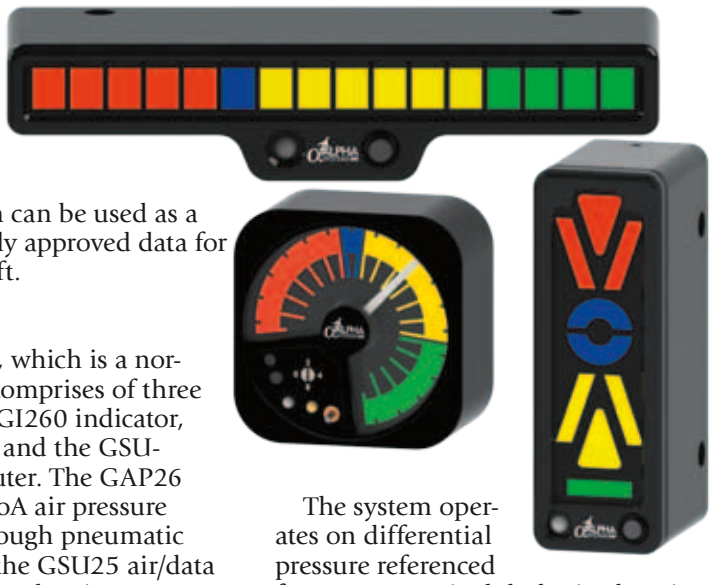
The newly introduced Merlin is similar to the Falcon, but presents AoA in a horizontal LED light bar.

For round displays, there's the Condor, which is a two-inch flush panel-mounted version. It's simple—aim for the blue LED when landing. The more LEDs that are on, the more lift you have.

Expect most complete Alpha AoA kits to cost roughly $2000, including the installation hardware, display and accessories. We like that many of the Alpha displays have up to 16 different LED brightness levels—

AOA SYSTEMS COMPARED

PRODUCT	PRICE	SENSOR TYPE	ASTM APPROVED?	COMMENTS
ALPHA SYSTEMS	$1995	PRESSURE TUBE	YES	Has the widest variety of AOA indicators, easy sensor install.
BENDIX KING KLR10	$1600	PRESSURE TUBE	YES	Made for Bendix King by Alpha Systems.
GARMIN AOA	$1499	PRESSURE TUBE, ADC	YES	Normalized AOA with dedicated air data computer and probe.
SAFE FLIGHT SCX	$1495	LEADING EDGE	PENDING	Measures stagnation point of the wing using leading edge sensor.
ADVANCED FLIGHT SYSTEMS	$895	PRESSURE	PENDING	Higher price adds wireless for remote app control, a feature GoPro White includes as standard for less money.



Garmin's normalized AoA system, upper left, uses a pitot tube, an air data computer and a glareshield-mounted indexer, top picture. It's approved for certified aircraft independent of existing avionics. Alpha Systems, grouped upper right, has a seemingly endless variety of AoA displays options.

from ultra dim to very bright. You can imagine how bright all of those LEDs can be in a dark cockpit, and variable dimming helps. There's also audio output with an audio mute switch for stifling the alerts.

A few words on AoA systems for pressurized aircraft: Expect additional approval. Alpha Systems offers a version of its AOA system for pressurized aircraft, which includes a fuselage-mounted controller unit.

However, when it comes to installing an Angle of Attack system in a pressurized vessel, it's important to note that FAA installation criteria issued to AOA manufacturers specifically excludes aircraft with pressurized cabins due to concerns about unrestricted penetrations of the pressure vessel.

As a result, the eligibility of an AoA system install that's accomplished as a minor alteration must be determined on a case-by-case basis. Generally, in accordance with FAA advisory circulars, penetration of the pressure vessel is outside the boundaries of a minor alteration, and major alterations require field approvals or STCs. But that doesn't mean approval is impossible.

Reader Jonathan Fisk reported that the installation of Alpha's AoA was approved in his Piper Malibu. That installation can be used as a basis for previously approved data for other PA46 aircraft.

GARMIN AOA

The Garmin AOA, which is a normalized system, comprises of three components: the GI260 indicator, the GAP26 probe and the GSU-25 air/data computer. The GAP26 sends pitot and AoA air pressure to the GSU25 through pneumatic plumbing, while the GSU25 air/data computer measures the air pressure inputs from the probe and from an independent static source and calculates an AoA solution. The GSU then communicates AoA information to the GI260 through an RS-232 serial data connection. The GI260 displays this AoA information to the pilot via 10 color-coded LED segments. After calibration, the system will indicate AoA through variable dimming of the LED-lit colored segments.

The Garmin AoA can also display on the company's G3X Touch integrated avionics suite, but we think the display is better positioned on the glareshield.

When connected to an available unswitched input of an audio panel or compatible audio system, the GI260 can also issue aural tone alerts when the system detects the onset of a stall condition.

Garmin's AOA indicator is simply designed and easy to interpret, in our view. When all four of the green bars and the Approach AoA green dot are displayed, you are on the correct AoA for an approach. As the AoA increases, yellow horizontal bars and chevrons illuminate and you hear a slow audible beeping. When the red chevrons illuminate and the audible beeping increases, you've increased the AoA further and are approaching a stalled condition.

Garmin's AoA is available in three varieties, including heated and unheated probes and 14-and 28-volt versions.

ADVANCED FLIGHT SYSTEMS

Advanced Flight Systems, the folks that make LSA and experimental integrated avionics, offers the AOA Pro and AOA Sport series AoA systems.

The system operates on differential pressure referenced from two 0.04-inch holes in the wing at about 20 percent wing cord. These also connect to a transducer and can be displayed on a simple, eight-LED display bar ($890 Sport model), on a LED display with both relative angle and a digital readout of actual angle ($1490 Pro model) or directly to one of the company's PFD displays.

The Advanced system has a flap sensor, so you calibrate it for both a clean and an approach flap setting for better accuracy. The display then corrects AoA automatically when the flaps are extended. The Pro system also has built-in gear-warning.

CONTACTS

Advanced Flight Systems
503-263-0037
www.advanced-flight-systems.com

Alpha Systems
763-506-9990
www.alphasystemsaoa.com

Bendix King
855-250-7027
www.bendixking.com

Garmin, International
800-800-1020
www.garmin.com

Safe Flight Instrument Corporation
914-220-1125
www.safeflight.com

As with most any non-certified system, the Advanced AoA installation manual has the following caveat: "Installation of the AOA on experimental aircraft is considered a minor alteration and as such does not require anything other than a logbook entry. Installation on production or certified aircraft requires FAA approval (Form 337) which may be difficult or impossible to receive. This experimental instrument is not FAA certified or approved."

That's not to say that FAA approval can't be acheived for certified aircraft. Advanced Flight Systems' Rob Hickman told us the company's systems are installed in Bonanzas, Skylanes and Caravans. Of course, that doesn't mean they're approved.

From our own experience attempting to gain approval of an Advanced AoA system in a Cessna, a major heartburn the local FSDO had was the systems interface with the flap system. Despite providing the office with detailed installation drawings, our FAA field approval request was shot down.

CONCLUSION

There are other systems we didn't cover, including the RiteAngle AoA (www.riteangle.org) which uses a mechanical vane and flap sensor to measure AoA, and the InAir Instruments (www.liftreserve.com) system. These are systems marketed exclusively for experimental planes, which is beyond our focus.

For AoA installations in certified aircraft, we suggest focusing on AoA systems that currently meet ASTM F3011 standards. While an FAA field approval could be possible (although lengthy) for a non-compliant system, we think there are enough worthy choices in certified systems.

Among them, we favor the Garmin AoA system because compared to lift reserve systems, it measures normalized angle of attack irrespective of loading, flap setting and atmospheric conditions. There are multiple components to install, which increases installation effort and cost.

On the other hand, after flying with the Safe Flight SCx, we're convinced that measuring the stagnation point is the simplest way of measuring consistently accurate AoA, even if it means waiting for an approved system and cutting into the wing.

SAFE FLIGHT SCX: LEADING EDGE

Safe Flight invented the stall warning lift detector system in 1946. Pioneered the lift transducer system in 1953. Invented automatic throttle systems utilizing angle of attack/coefficient-of-lift guidance. How a company with these—and countless other industry-leading accomplishments—can have so much trouble gaining FAA approval for a basic angle of attack system for GA aircraft may seem mind-boggling.

But compared to some of the other AoA system manufacturers, Safe Flight Instrument Corporation with its new SCx AoA system is at a distinct disadvantage. It has nothing to do with its experience in the industry, the accuracy of its system or the skill of its certification staff. Instead, it has everything to do with the mounting location of the SCx AoA sensor, which is installed in the leading edge of the wing.

The SCx is the second generation of Safe Flight's AoA/speed control system and has a newly designed AoA indexer that also houses the AoA computer. When we flew with the first generation of the system a year ago, Safe Flight was struggling to gain FAA approval because the leading edge sensor used in determining AoA requires cutting the leading edge of the wing—a major modification by most standards.

Still, Safe Flight is convinced that a leading edge AoA sensor is the only accurate way to consistently measure AoA. Safe Flight leading edge sensors have been certified for primary stall warning on OEM aircraft for years—everything from single-engine pistons to high-performance military and transport jets and everything in between.

Using an electromechanical lift transducer that is similar in form factor to the familiar stall warning vane, the SCx system measures the flow field about the wing's leading edge. The operative term is stagnation point—the area of the wing where air isn't flowing under or over it. As AoA increases, the stagnation point moves aft on the wing until a critical threshold and ultimate stall occurs. The relative wind in relation to vane effects an action either up or down on the sensor, depending on the angle of attack. The transducer converts the action to an angle of attack value that's displayed on the glareshield-mounted indexer/computer.

Safe Flight says that wing-mounted transducers have advantages over differential pressure transducers, which can be less accurate in low airspeed and slip conditions.

The LED-equipped indexer (which we wish were brighter) provides a flashing red output as the aircraft nears the stall AoA, while an audio output that resembles a Geiger counter sounds in the headset. The indexer has a sliding reference marker that allows you to change the focal point for referencing best rate and angle of climb, best short-field approach AoA and best cruise AoA when flying into a headwind or with a tailwind.

Safe Flight is currently working with the FAA to gain certification status of the product, but until that's finalized the $1495 SCx system can only be installed in experimentals.

Aside from cutting the leading edge of the wing to mount the transducer, installation is straightforward, unlike certification.

Savvy Analysis: Protecting Your Engine

Savvy Analysis Pro, the subscription program that analyzes your engine monitor data, has a new service: It will notify you if you have a failing exhaust valve.

Staff Report

In the years since Savvy Aircraft Maintenance Management (SAMM) (January 2009 *Aviation Consumer*) brought managed aircraft maintenance from the turbine to the owner-flown piston world, the company's practice of analyzing the engine monitor data of its clients has resulted in the collection of a massive database. According to company founder Mike Busch, it has the engine data from more than 600,000 flights.

Although engine monitors were originally developed to help pilots lean their engines in flight, the parameters they collect include extensive information on the operational health of the engines. SAMM has been using the data to diagnose problems in its customers' airplanes—to catch developing issues before they become expensive.

SAMM began looking for a computer tool to do engine monitor data analysis more efficiently. Chris Wrather, who had been involved with SAMM from its early days and holds a Ph.D. in operations research, took the lead and developed analysis tools that work in fractions of a second.

Initially, the analysis tools were only used in-house, however, as they proved effective, the decision was made to make them public and free. Thus, Savvy Analysis was born to further the mission of SAMM—to help aircraft owners do a better job of operating and maintaining their aircraft—as well as to add to SAMM's database for its ongoing research. SAMM and Savvy Analysis do not share the data they receive with anyone; however, the person who uploads data may share it with others.

Engine monitor data showing the characteristic rhythmic EGT cycle of a failing exhaust valve; number 3, depicted in yellow. Top photo shows the entire flight; bottom is a close-up.

FREE SERVICE

Users can upload data from any type engine monitor. The Savvy Analysis software opens and displays it in graphic format, sorted by flight. The user can then sort his or her flights as desired and take advantage of the analysis tools on the site. There is

CHECKLIST

- Savvy Analysis uses engine monitor data to detect problems early.
- Free service allows owners to use sophisticated analysis tools on the site.
- New Failing Exhaust Valve Analytics warns of burned exhaust valves.

what we consider to be a user-friendly operating guide that helps the user get into and understand the graphically displayed data. Moving the cursor along the data provides a digital readout of each parameter—including temps, fuel flow and time—in what is referred to as a dynamic data box.

The software allows the user to look at the behavior of just the odd- or even-number cylinders to see if the mags are timed the same and can choose intervals in the data to find differences and rates of change.

The GAMI lean test has become the standard for checking the balance of the fuel injectors and to identify problem cylinders. When a user has conducted a GAMI lean test during a flight, the software will automatically calculate the GAMI spread for each test.

SAVVY GOES PRO

After six months, Savvy Analysis offered a "Pro" service—after paying $129 ($199 for twins) for an annual subscription, a customer who uploads data can have as many flights as he or she wishes analyzed by one of Savvy's analysts—who then generates a two-page report on the engine health on each flight. (The Savvy Analysis Pro service is included in the price of the managed maintenance service offered by SAMM.)

While an analysis could be requested for every flight, doing so would eventually drive up the price of the subscription and wouldn't provide much relevant data.

Both Wrather and Busch recommend having the engine monitor data from a flight analyzed just before the airplane is going into the shop for engine work—to identify any problems so they can be fixed on that shop visit—and after work has been done on the engine, ignition, mags or induction system.

They also recommended that the flight to be analyzed not just be a routine cross country, but a test flight made according to the protocol on the website—essentially a GAMI lean test at less than 65 percent power and a lean of peak mag check to check the ignition system when it's under the most stress.

Doing a test flight before a shop visit, uploading the engine data to Savvy Analysis and then clicking on the little "Sigmund" icon requests full analysis of that flight and generates a printed report that can be provided to the mechanic who is about to work on the airplane. It's a fast diagnostic tool and much cheaper than trying to uncover such things as incorrect fuel flow, exhaust and induction leak and mistimed mags when the airplane is sitting on the ground.

Exhaust valve with burn areas noted—on exhaust valves, green means stop.

FEVA

Recently, Savvy Analysis added a new, automatic service for its Pro customers (which includes all managed maintenance customers of SAMM)—Failing Exhaust Vale Analytics (FEVA). When you upload your engine monitor data, Savvy's system automatically scans the EGT temperature readout and uses a proprietary algorithm to look for a signature that is indicative of a failing exhaust valve. If the characteristic pattern exists, the software flags it and starts the process that results in a warning to the owner and recommendation to borescope the cylinder.

FEVA came about as a result of observations Mike Busch made of engine monitor data more than 10 years ago. He noticed that for as much as 150 hours of engine operation prior to the time an exhaust valve fails, it generates a distinctive EGT pattern—an approximately one minute-long cycle over a 30- to 60-degree range.

He noted that the rotator cap that sits on the top of the exhaust valve stem—between the rocker arm and valve—and rotates the exhaust valve a fraction of a degree every time the valve opens and closes, causing about a one RPM rate of rotation of the valve. The purpose of the rotator cap is to spread the heat load on the exhaust valve around its circumference so one spot isn't always being exposed to maximum heat. Rotation also helps inhibit buildup of exhaust deposits on the valve seat. (There is no rotator valve on the intake valve

Valves in the cylinder—burned exhaust valve shows nonsymmetrical color pattern and green burn area at lower, left edge.

as it is not exposed to the same heat or exhaust deposit potential and the exhaust valve.)

As an exhaust valve starts to go south, becoming a burned valve, it develops a hot spot where it is not sealing perfectly with the seat—very hot gases from a combustion event begin to leak past the valve. Metal erosion begins and the valve can warp—causing the hot spot to get hotter and more gases to leak. Once it starts, the valve progressively goes downhill.

Ultimately, the valve will fail and a chunk of metal from the area of that hot spot breaks off, the cylinder goes to zero compression and stops combusting—the little piece of metal departs through the exhaust system. If it's a turbocharged engine, it's the luck of the draw whether the piece processes through the turbocharger, doing further damage, or the waste gate directs it harmlessly out the tailpipe.

BORESCOPE IT

Burned valve damage is typically visible through a borescope between 50 and 150 hours prior to failure. A compression test is far less reliable, according to Busch, giving too many false positives. The borescope is the gold standard for determining impending valve failure—and the engine monitor is the early warning system that says when it's time to do the borescope exam.

The picture that a failing exhaust valve paints on the EGT graph of engine monitor data is a slow, perfectly rhythmic oscillation of the EGT for the affected cylinder. Busch said, "The pattern is easily distinguishable from EGT data 'noise.' There isn't anything else in the engine that can oscillate that slowly. Normally the amplitude is pretty small. We normally look for an oscillation of 30-60 degrees from peak to peak. When we see it, we know the valve is failing."

Busch and his team developed an algorithm that spots this pattern in engine monitor data. As part of the subscription price for SAMM or Savvy Analysis Pro, a customer's engine data is automatically put through the FEVA algorithm when the engine monitor data is loaded.

If the algorithm finds a failing exhaust valve, the four analysts at Savvy, including the chief analyst, Adam Hall, are notified immediately. If they determine that there is a risk of a failing exhaust valve, one of them contacts the customer. Busch says that the plan is for the system to automatically notify the customer in the future—right now they're tweaking the algorithm, so they're keeping an analyst between the computer and the customer.

The customer is advised that Savvy has detected what they believe is a failing exhaust valve, and which cylinder is involved. Savvy recommends to the customer that he or she have the affected cylinder borescoped. Savvy also requests that the customer send copies of any images made of the affected valve to Savvy, both for feedback to fine tune the algorithm and to let Savvy personnel look at the condition of the affected valve.

Busch said that Savvy will never recommend that a customer pull a cylinder based on FEVA alone—the borescope is the final diagnostic instrument for that decision. If the borescope reveals a valve that is exhibiting the characteristic asymmetric appearance and discolorations (green is bad) of impending failure, Savvy recommends that the cylinder be pulled and revalved.

Busch noted that few A & P mechanics have been trained in using a borescope and interpreting what they see. He strongly recommended—and we concur—keeping a copy on hand of the full-color poster put together for the Air Safety Foundation by Adrian Eichhorn and Dr. Peter Wu that shows healthy and deteriorating exhaust valves. It's available at: http://tinyurl.com/op469zk.

UPLOAD THE DATA

Savvy is working to get its clients to upload engine monitor data regularly—just as they send oil out for analysis at every change—not just when they think there's a problem.

He and Wrather also recommend a flight test, data upload an analysis before the annual inspection, before any engine work and after engine work. Having a printout of the engine's health to hand to the mechanic who's going to be head first into your airplane's cowling can, in our opinion, save money by letting him or her fix small problems before they become large.

We like the Savvy Analysis concept—the new FEVA program is, to us, additional protection at no extra cost. We also like the fact that the basic Savvy Analysis program is free, so owners can upload data and do their own analysis using the tools on the site. Savvy Analysis is at www.savvyanalysis.com.

In the interest of full disclosure, senior editor Rick Durden contributed to this report. He is also an attorney. Mike Busch was a client of his prior to and during the first year of operation of Savvy Aircraft Maintenance Management.

Great Lakes Biplane: Docile, Sporty and Fun

Built by Waco Classics, this classic bipe is looking for a training and sport market. It's capable of more than casual aerobatics and it's a pussycat to land.

CHECKLIST

- The Great Lakes is true to the original and superbly detailed and built.
- It's been significantly modernized with a lifetime airframe and digital avionics.
- For a 1930s taildragger, the 2T is surprisingly easy to handle.

by Paul Bertorelli

Economists have a name for things that are in daily use despite having been designed multiple decades ago: persistent technology. Biplanes fit the definition, although pilots don't call them that; they call them fun, an even mix of nostalgia and unique performance characteristics. That more than anything explains why biplanes have been in and out of production since the 1930s and the latest one to go into production is the Great Lakes 2T-1A-2, a modern revision of the classic biplane made famous by barnstormer Tex Rankin.

Waco Classic Aircraft, which builds the hulking Waco YMF-5, is pitching the Great Lakes as the perfect combination of sport aerobat and a trainer for upset recovery, which some pilot courses now require. At $245,250 complete, it's not cheap, but as new airplanes go, it's also hardly out of reach for buyers who can afford new and want something that's more unique than practical, the market niche that Waco plies to sell up to eight YMF-5s a year at a price north of $400,000.

The word "classic" is often applied to anything with two sets of wings, but it's one that the Great Lakes has fairly earned. Interestingly, from day one, the original 2T was sold as a sport trainer for the discerning pilot who wanted something smaller than the massive Waco and who fancied occasionally tossing the airplane around in aerobatics. It found use as a basic trainer from the early 1930s onward. The original airplane

The 2T's panel, above, is minimal, with a JPI 930, Garmin aera GPS and TRIG comm. Turtledeck compartment, left, doesn't qualify as a baggage area.

was no slouch structurally, claiming plus 9G and negative 6G capability; the new 2T is built for plus 5.4 and negative 4.0.

In its various vintages, the 2T has had several engines, including the original's Cirrus, a four-cylinder inline engine, another inline called the Menasco and later a Warner radial. The Lycoming O-360 came along during the 1970s. Well into the 1960s, the Great Lakes was the aircraft of choice for a number of aerobatic champions and airshow pilots, including Betty Skelton and Charlie Hillard. It was eventually displaced by the Pitts, a smaller bipe yet, and later by various monoplanes such as the Extra line.

Compared to the Waco, the Great Lakes was—and is—relatively diminutive, with a wingspan of 26 feet 8 inches and a maximum takeoff weight of 1800 pounds. The YMF-5, by comparison, has a 30-foot wingspan (top wings) and a gross weight of 2950 pounds. It's also a three-place airplane, with a spacious bench seat in the front hole. Not the Great Lakes, though. It's a snug fit front and back.

Thanks to its good manners and reasonable acquisition and operating costs, the 2T lived on through the 1960s as a homebuilt. During the 1970s, a few were built in Eastman, Georgia, but right up into the 1990s, the plans-built airplanes were still seeing some action. In 1973, Doug Champlin had the airplane in production briefly in Oklahoma and in 2000, John Duncan bought the type certificate and tooling and announced, once again, a plan to return the 2T to production under the flag of the Great Lakes Aircraft Company. And that's where Peter Bowers of Waco Classics comes in.

WACO SYNERGY

Bowers learned of the Great Lakes 2T by chance from one of his Waco customers who had one of the older airplanes. He took a ride in it around San Francisco Bay and was hooked.

"But there were some things I didn't like about it. The fabric was old and had holes kicked in it through the cockpit sides. The windscreen cut me right in the forehead and the backseat was cramped. The fact that you were sitting in an all-fabric structure…it felt like you were in a glass bowl and you were going to break something," Bowers says.

Although Duncan had planned to resume production of the airplane, with a production setup already in place in Lansing, Michigan, Bowers made an arrangement with Great Lakes Aircraft Co. to build the 2T in Lansing, improving it considerably in the process.

"We were looking for a new project. We were thinking of maybe a legacy LSA. But I couldn't figure out how you could possibly make money at selling an LSA. I just couldn't make it work. Developing a new type was out of the question," Bowers says.

So Waco Classics took on the project and began improving the airframe. While the 2T retains the same basic planform and dimensions of the original, it looks different enough that people who see it on the ramp might ask, "That's not a Pitts, is it?" Perhaps the biggest cosmetic change is the cowling and nosebowl, which is tapered and more aerodynamic than the squared-off original cowling, especially models that had the Warner radial.

Bowers says he considered upgrading the engine from the IO-360 to the 200-HP variant or perhaps the 210-HP IO-390, but in addition to the weight hit, the project would have been prohibitively expensive for the small volume the 2T is likely to generate. So the new 2T has a 180-HP AEIO-360-B1G6 with full inverted systems.

In addition to the incremental engine improvement, the airframe also has some upgrades. Before it undertook restarting manufacturing, Waco Classics sent an engineer to study four Great Lakes in regular use by a flight school in Arizona for introductory aerobatics and upset training.

"That gave us a litany of things to fix," Bowers said. The only significant structural fix was the horizontal stabilizer spar,

which showed a propensity to crack. It was replaced by a steel part that's a bit heavier but also much stronger. The airframe structure is conventional rag and tube, with German- or U.S.-made chromoly 4130 tubing internally treated with linseed oil and coated with an epoxy paint for what Bowers calls a lifetime airframe. The cover is Ceconite with PPG polyurethane paint.

To improve durability around the cockpit, the side skins are metalized and removable for maintenance access. In place of the original heel brakes, the new 2T has toebrakes.

"Owners hate heel brakes," Bowers told us, "They're difficult to modulate when you're operating the rudder." The airplane has a new Hartzell two-blade metal prop or the option of a three-blade MT. The induction system has also been redesigned to correct a potential safety issue with SCAT tubing that could collapse with age. Chronic high oil temperature in the old airplanes has been addressed with a larger oil cooler and lighting has been upgraded to LEDs all around.

BETTER ERGOS

The cockpit has also been improved, with a slight recline to seat. "Frankly, the original was very uncomfortable. It was built for pilots of the 1930s so it was upright and cramped," Bowers says.

The marketing brochure advertises 1275 pounds empty, but the first two built were heavier, at 1298 pounds for a useful load of 502 pounds. With full fuel (26.7 gallons in a single tank in the center wing), that leaves room for two standard FAA humans—just. Bowers says the finished airplanes might make the advertised weight with lighter paint jobs, but we're not sure another 25 pounds would make much difference. Two people and full fuel is about all this airplane needs to do and it remains in the aerobatic category at that weight.

Since we first looked at the 2T three years ago, the panel has been upgraded with new avionics and Waco has added ADS-B capability. Spacious new cockpit or not, there's not much room in the panel for major avionics. The panel in the demonstrator we flew was dominated by a JPI 930 large-screen engine monitor and had a Garmin aera GPS for navigation. For a combination comm and intercom, the 2T has the miniature TRIG TY91 and an ADS-B Out-capable TRIG TT22 transponder.

FLIGHT TRIAL

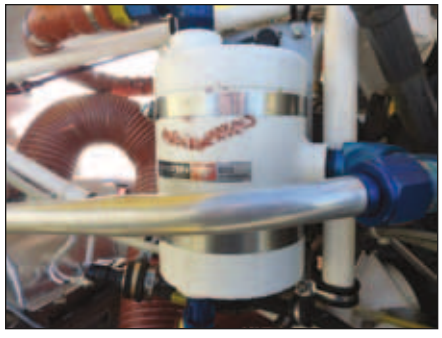
Flying an open-cockpit biplane requires a resetting of expectations. For one, ground and flight visibility is compromised by being hemmed in by two wings and having the forward view blocked during taxi. Still, from the rear hole, visibility in the 2T is quite good because its deck angle is modest compared to other taildraggers and it's relatively narrow. S-turns on taxi are needed, but just barely.

But the 2T's slim waist yields a snug cockpit and the only place to store things like charts or an iPad is in a small mailbox-type metal box on the center console. If you don't have what you need before you get in, there's no fishing around for it in flight. There's a small turtle-deck compartment behind the pilot's head, but it's not even a baggage compartment in name. If you're traveling in this machine, it's a one-person airplane, with baggage strapped in the front seat.

During run-up, Bowers explained—and the POH reiterates—to hold the stick full back and limit the RPM to 2300. Otherwise, you risk a noseover and indeed, during runup, the tail feels light. Moreover, the toebrakes are powerful enough to lock the wheels and cause a noseover during landing or fast taxi. The brakes aren't touchy, but they won't tolerate abusive inputs.

With its light weight, the 2T is easy to taxi and accelerates quickly on the runway. The tail comes up with no undue effort and the airplane is ready to fly at 55 or 60 MPH indicated. Best rate is 76 MPH, which will yield about 1200 FPM with two aboard, but better than that solo.

It's easy to see why the Great Lakes remains such a well-liked aerobat. Its handling seems to hide no surprises and it's comfortably responsive without having the excessively light stick forces that hamper some LSAs. Roll rate is brisk, but not head snapping. We did notice a sharp left wing drop during a stall series, but Bowers insists this isn't normal for the airplane. He said his own stall tests didn't reveal this behavior. A quick stab on the rudder brings the wings easily to level. With all that wing area—187 square feet for a wing loading of 9.6 pounds per square foot—the 2T is happy in slow flight right through the stall burble, retaining some roll control to the bitter end. In cruise, it has little noticeable adverse yaw, but more in slow flight, as to be expected.



The Great Lakes' AEO-360, top and lower, has a full inverted system. Toe brakes, center, improve ground manners.

continued on page 32

COCKPIT ACCESSORIES

GoPro or Garmin? Hero Outside, VIRB Inside

Both of these cameras are worthy choices and perform similarly for aviation photography. Garmin's VIRB has the edge in ease of operation.

by Paul Bertorelli

In an age of shameless navel gazing and epidemic self-absorption, how do you know if something really happened if you don't have a clip of it on your YouTube channel? Thus, the profusion of so-called point of view (POV) cameras that can grab video from perches unimaginable a decade ago—including airplane wings and cockpits.

GoPro dominates this market with a line of cameras at three price points, but there's competition, most recently from Garmin, which is taking on GoPro with its VIRB action cameras. Cameras might not seem a natural fit for a GPS company, but Garmin has leveraged its presence in the sports/fitness segment and tailored these products to aviation, offering unique capabilities. There are other options, too, including the revitalized Contour, the Sony Action Cam, the JVC Adixxion and the Panasonic HX line. But because this is a limited interest area for pilots, in this review, we're focusing on a head-to-head between GoPro and Garmin. Either, it turns out, is suitable for aviation photography.

If your iPhone or Droid hasn't yet displaced that old camcorder you used to have, POV cameras are more like the former than the latter. They're simply miniaturized and ruggedized video sensors in hardened, sometimes waterproof, cases suitable for sports or high-impact activities. Forget things like on-the-fly zooming, exposure compensation, or in-camera editing. What you get is a fixed focal-length lens with an HD sensor (video and still), audio recording, time lapse and slo mo and limited playback capability in a small package. Also, a low price. GoPro's cheapest bundle sells for under $200 and the top of the line, the Hero3+, is $399. Garmin's VIRB isn't quite so inexpensive on the bottom end, but its Elite ($329) is comparable to the Hero3+, even if the comparison isn't a perfect fit.

Although these cameras do the same thing and are similarly aimed at action sports, they do the job differently. Accessories, and especially operating logic, vary. For instance, if you don't need remote wireless control—we're not sure it's worth the bother or expense—the complexity of each system is less and, for the VIRB, so is the cost. Also, the number of parts and pieces with these things—mounts, arms, cable adapters, converters, viewers, remotes—will challenge the most organized, leaving the scatterbrained among us perpetually wondering where all those bits got to.

GOPRO

GoPro's current line has three products, the Hero3, the Hero3+ Black and the Hero3+ Silver. These vary in price and capability. First the commonalities. All three shoot video up to 1080p, but the Black and Silver

POV CAMERAS COMPARED

PRODUCT	VIDEO SPECS	PHOTO SPECS	VIEWER	REMOTE	APP	PRICE	ADD-ONS	COMMENTS
GOPRO HERO3 WHITE	1080P/30 960P/30 720P/60	5MP/ 3 FPS BURST	OPTIONAL	OPTIONAL	IOS/ DROID	$199.99	LCD VIEWER ($79) REMOTE ($79)	Good basic camera, no frills. Plan on using with app for remote viewing.
GOPRO HERO3+ SILVER	1080P/30 960P/30 720P/120	10MP/ 10 FPS BURST	OPTIONAL	OPTIONAL	IOS/ DROID	$299.99	LCD VIEWER ($79) REMOTE ($79)	Similar to White Edition, but with higher still res and better slo mo. Still needs the app or LCD viewer.
GOPRO HERO3+ BLACK	1080P/60 960P/100 720P/120	12MP/ 30 FPS BURST	OPTIONAL	INCLUDED	IOS/ DROID	$399.99	LCD VIEWER ($79) REMOTE ($79)	Most capable GoPro, but over-priced for aviation use, in our view.
GARMIN VIRB	1080P/30 960P/48 720P/30 WVGA/120	16MP/ 10 FPS BURST	STANDARD	OPTIONAL	NO	$249.99	NUMEROUS ANT+ ACCESSORIES REMOTE ($49.99) D2 WATCH INTERFACE	Recently lowered price makes this a good value against GoPro White. Ease of operation is a plus.
GARMIN VIRB ELITE	1080P/30 960P/48 720P/30 WVGA/120	16MP/ 10 FPS BURST	STANDARD	OPTIONAL	IOS/ DROID	$349.99	NUMEROUS ANT+ ACCESSORIES REMOTE ($49.99) D2 WATCH INTERFACE	Higher price adds wireless for remote app control, a feature GoPro White includes as standard for less money.

will shoot 1080p up to 60 frames a second and the lesser resolutions at 100 and 120 frames, which yields smooth slow motion footage—useful, maybe. For stills, the White offers 5 megapixels at a 3 fps burst, the Black has 12MP/30 burst and the Silver 10MP/10 burst. All three will do automatic time lapse between a quarter second and a full minute.

The GoPros are shipped with a clear plastic case and they need it to both protect the camera and provide mounting means. Although GoPro mounts are available in great profusion, there's no ¼-20 insert for standard accessories for tripod mounting without the case. (Buy the aftermarket fixture.)

GoPro provides pressure-sensitive pads for helmets and flat or curved surfaces. These will adhere to windshields or even aircraft external surfaces without worry of losing the camera. They'll also adhere to things like glareshields or overhead panels for shooting cockpit footage or time lapse. RAM sells a ball mount for the GoPro and with that, you can attach it to about anything with fully articulated aiming.

For remote audio, say to record ATC or intercom chatter, you'll need GoPro's USB-to-3.5mm adapter, which will accept an external, unpowered mic. With an adapter, you can tap directly into the ship's intercom.

Controlling and viewing the GoPro's video isn't necessarily simple. The camera's control logic has been a source of complaint since it first appeared seven years ago and it hasn't improved much, in our view. It requires a clunky combination of menu step throughs with the front power button and execution of menu commands with the top or shutter button. Intuitive it's not. It yields to regular use, but occasional users are likely to accidently switch to still shots or some other mode when video is wanted.

The GoPro has no viewer, so framing the shot is a best-guess affair. But the lens is so wide, it's like close range with a shotgun. There are two workarounds for this, the LCD BacPac and/or a wireless app that controls the camera. For $79.99, the BacPac is a snap-on screen that gives the camera both a viewer and a touchscreen that simplifies the menu navigation—a little. The touchscreen isn't quite as responsive as an iPhone, but it's functional and provides useful playback capability.

All three GoPro cameras are wifi capable and suitable for use with the GoPro dedicated remote control. The Black Edition includes the remote, but it's a $79.99 option with the other two models. The best alternative to avoid buying either the remote or the BacPac is GoPro's free wireless app, available for IOS or Android. It allows

Playback isn't the VIRB's best trick; screen is small and muddy, top photo. GoPro with the BacPac, center photo, is better, but you'll pay extra for it. Yes, those cameras will stay on the wing, just don't plan on any Vne dives.

REALLY CHEAP VID

Our market scan turned up a basketful of $300-plus cameras and one sub-$100. This truly cheap camera is sold as the SJ1000 or the Sports HD DV. It may have other names, too. Find it for as little as $65 on Amazon. Now let's get serious here—this costs well under half of even the least expensive GoPro, so it can't possibly be other than a curiosity, right?

Wrong. The SJ1000 has an impressive featureset including 1080p down to VGA and up to 12MP for stills. As standard equipment, it has a small, vibrant LCD viewer that puts the VIRB to shame. It comes with so many mounting brackets and accessories that we still haven't figured them all out.

Image quality? Better than we imagined, but it appears to need just the right lighting to produce crisp images and we're not sure how durable it is. But for $65, not bad.

easy remote control of the camera, makes the menus somewhat easier to manipulate and provides playback. But the wireless has so much latency that using it to frame the shot requires patience; it will work, just not quickly.

GARMIN VIRB

Garmin's appropriately if weirdly named VIRB—get it, action as in verb?—came out of nowhere a year ago. In taking on GoPro, Garmin is dancing to a different tune. For one, the camera's form factor is long and narrow compared to GoPro's basic box. It also requires no separate case for moisture protection and, like Garmin's GPS products, it's easier to operate. Pricewise, it's competitive.

There are two models. The top-of-the-line VIRB Elite at $349.99 and the base VIRB at $249.99. Both cameras will shoot up to 1080p at 30 frames, 720p/60 and WVGA at 120 frames for slow motion. Like the GoPro, the VIRBs will do photo bursts and time lapse stills to similar specs. Still size is 8 to 16 megapixels in both models. Both have internal mics and external audio through a USB-to-3.5mm cable.

While the VIRBs appear to be more expensive than the GoPros, this isn't the case when you compare like capabilities. The VIRBs have a built-in thumbnail viewer for aiming and playback, so if you add the GoPro's $79 BacPac viewer to get the same capability, the prices are less, although the GoPro's BacPac is larger and more vibrant. Both models can be controlled remotely, the VIRB through Garmin's D2 watch and the Elite through both the watch and a dedicated remote control.

Garmin also gave the VIRB a mounting system that's easier to use, in our estimation. The camera snaps into a cradle which in turn fits into a base screwed into a plate that attaches with pressure-sensitive adhesive. In our view, this works better than GoPro's sliding snap system. However, you pay for the convenience; the adhesive mounts, which are expendable items, cost twice as much as the GoPro pads—about $19 for six versus $10 for the GoPro.

Where the Garmin excels is in operating logic. It has four dedicated—and labeled—keys for power/mode and menu navigation. The side slide switch has but one fuction—forward to record, aft to stop. Pick the camera up in any mode and slide the switch and you're shooting. The VIRB's viewer—standard—is tiny at 0.75 by 1.06 inches, but is adequate for framing and basic playback. For framing, it's not as hobbled by latency as the GoPro wireless app is. While we're on wireless, the VIRB Elite has this capability and can be operated remotely through Garmin's free app on IOS or Android devices. The app works well and it's easy to use, but lacks two things we think it needs: playback capability and live streaming. The GoPro does that, albeit not exceptionally well.

The VIRB uses the ANT+ network protocol to connect itself to other devices such as heart monitors, navigators and other sports-related devices. Naturally, since Garmin is a GPS company, the VIRB has its own GPS aboard and records track data which can be incorporated in finished videos using VIRB Edit, Garmin's video software for the Mac and PC.

WHICH ONE?

Picking one of these cameras over its competition isn't simple because they don't have parallel capabilities. For a pilot or owner who's also into sports and wants to shoot same, the VIRB is the better choice. It's waterproof out of the box (IPX7 rating) and connects to other devices via ANT+. It can be a powerful training and tracking tool for users who like gadgets.

Since aviation also involves training (and gadgets), the VIRB would be our pick for in-cockpit shooting of flight lessons or just flights you might want to record to wow the inlaws. Pipe in the audio from the intercom and the VIRB will capture everything for review. Add track data and you've got a nice visual record of the flight.

For attachment outside the aircraft, we prefer the GoPro. Its small size and cubic form makes it easier to mount just about everywhere and the low profile offers less drag and less worry about losing it. The pressure-sensitive pads are strong enough to preclude this, but faith in chemistry has its limits.

Image quality between the two is comparable, but strongly lighting dependent. The VIRB yields a warmer image that's sharper in the distance and it does better in harsh midday light than the GoPro.

The GoPro is a little bluer and softer in the mid-and far distances and doesn't like contrasty, midday lighting. Given the apps, accessories and performance available, you won't go wrong with either choice, in our opinion.

PMA450 Audio Panel: True Dimensional Sound

A new plug-and-play audio control system from PS Engineering that enables you to spatially position audio sources in different areas of the headset.

by Larry Anglisano

An impressive trait of audio maker PS Engineering is its drive to improve and advance products that would otherwise remain cutting edge for years to come. It seems every time I evaluate one of its feature-packed audio panels, a new model with more capability comes along a year later.

This year at AirVenture, PS Engineering introduced the $2395 PMA450, a slide-in replacement for the company's PMA8000-series audio panel. It's a product that I thought had more than enough functionality and features—perhaps more than some pilots use.

But the PMA450 packs more than additional features. Instead, it has new digital audio processing technology that puts it on a level playing field with Garmin's GMA350 retrofit audio system.

INTELLI AUDIO

That's what PS Engineering calls the patented technology that it licensed from the United States Air Force. Since fighter pilots (and GA pilots, perhaps to a lesser extent) are inundated with multiple types of audio signals at once, the branded IntelliAudio—which Air Force pilots know as Multi-talker—helps present the audio sources in a way that's more intuitive to process, or at least in a way that mimics how the human ear hears and registers sound.

IntelliAudio places Comm 1 and Comm 2 audio in various positions within the stereo headset, making simultaneous incoming radio signals sound as if they are coming from different locations.

For example, the user can place the signal sources in nine unique positions. The intent is to make it easier for the pilot to concentrate on the radio of choice while ignoring the radio of lesser importance at the time. For example, the pilot can choose to pay attention to ATC while ignoring an ATIS broadcast, depending upon what is pertinent at the moment.

This distracting situation always seems to overload my brain and if I'm listening to an ATIS broadcast on the second radio while monitoring a busy approach or tower frequency on the primary radio, I'm constantly turning the ATIS volume off when I hear activity on the primary radio, even if the call isn't for me.

With IntelliAudio, you can place the ATIS in a different location within the headset so the brain can more easily discern one source from the other.

CHECKLIST

- Audio setup and configuration is presented in an easy feature set.
- Dimensional audio could reduce workload when using multiple radios.
- How about a color display to better handle bright sun?

VISUAL SETUP

While the PMA450 brings many of the same functions found on the PMA8000 panel, there is a new user interface that utilizes a graphical display with three soft keys that PS Engineering says helps the user visualize the system setup—essentially eliminating a pilot guide. The display is LCD, which isn't great in bright sunlight. There is a brightness and contrast adjustment, however, which helps. There's also a menu screen timeout function, where the user can adjust how quickly the screen reverts to the main menu.

To adjust or relocate audio sources for dimensional sound, the PMA450 uses a Head Related Transfer (HRT) function that's accessed onscreen. Press the IntelliAudio soft key, where there's an option to turn the function on or off (you can still use the panel in a traditional configuration) and select the IntelliAudio Config

The PMA450, lower photo, shares the same chassis and interconnect wiring as the popular Garmin GMA340 and PS Engineering's own PMA8000 audio panels, making installation plug-and-play.

PMA450 CONTROL SET

option. Once in the IntelliAudio mode, repeated pressing of the Comm 1 or Comm 2 line select keys moves a corresponding half-circle cursor to the locations relative to the listener graphic that's on the display. Press Done to exit and save the configuration, where it's recalled at every system power up.

A comm monitoring mode takes the interface one step further by allowing the secondary radio audio to be muted by the primary radio (or the one being used for transmissions) when there's activity. This essentially automates my process of cranking the volume down when listening to ATIS on the second radio. the bottom soft key serves double duty for speaker activation, enabling the internal speaker amplifier.

The front panel has dedicated nav receiver keys, while switched audio input sources (traffic and terrain system audio, for example) can be configured for onscreen selection, based upon the wiring. The default switched inputs are for ADF and DME audio, but the user has access to rename the inputs—up to nine letters per line.

MORE UTILITY

The PMA450 brings all the failsafe, intercom and entertainment input capabilities found in the PMA8000 and the recently introduced PAR200 budget audio panel (see the September 2013 *Aviation Consumer* for a review). These features have been standard on PS panels and intercoms for years, so I won't cover them here.

As I've found with the company's other products, the adjustment-free IntelliVox squelch circuit is flawless. While non-voice signals are blocked, only voice activity opens the squelch.

What is new is onscreen Bluetooth telephone control and a USB plug-in. When the phone rings, an incoming call menu opens, showing caller ID. Simply answer the call by pressing the top line select soft key on the display.

The only problem is since the phone uses an intercom circuit, all stations on that circuit lose intercom capability when the phone is in use. It's not a big problem—because do you really use a cell phone for long periods during flight?

The panel comes standard with an internal digital recorder that captures the last incoming audio from the radio that's selected for transmit. It stores up to eight messages and up to 45 seconds of audio. Playback is simple—press and hold the comm receiver button for one second. It's nice to see this utility as standard.

THE BETTER WAY

I think PS Engineering's Dimensional Sound IntelliAudio really is a better way of processing multiple audio signals. Frankly, I dismissed the technology when I first used Garmin's 3D audio feature that's present on the GMA350/35 audio panel because I found it to be overwhelming, especially when passengers are talking on the intercom.

In my estimation, PS Engineering did a good job of designing the HTRF function so that it's easy to configure and change on the fly. When I flew with it, I positioned Comm 1 in the left side of the headset and Comm 2 on the right. It seemed to be a logical configuration, based on a standard radio stack configuration. But on panels that are nonstandard (maybe the second Comm is located on the left side of the panel), you can adjust the audio to play where you want it.

The positioning of the audio was so precise that I often forgot the audio was confined to the headset. That speaks volumes about the technology in general. Contact www.ps-engineering.com, 865-988-9800.

Bug Off: Cleaning Leading Edges

Cleaning bug splat off leading edges isn't a big deal—if it's done right after a flight. Wash Wax All makes a tough job easier for procrastinators.

by Rick Durden

CHECKLIST

- Smashed bugs degrade aircraft efficiency and can damage paint.
- Not cleaning bugs off immediately after flight means more work, later.
- The combination of Wash Wax All and an Aero Scrubber Pad works well.

Bugs have been defined as small flying creatures that hurl themselves at airplanes intending, through sheer numbers, to deprive them of flight. While not nearly as effective as icing in changing the shape of a wing's leading edge, a layer of bug splat does affect performance and efficiency.

Once bugs give their all against a leading edge, the process of decay of makes their remains progressively more difficult to remove. Plus, the enzymes released during decay can damage the paint. Taking 10 minutes as part of a postflight to clean fresh bugs off requires less work and less sophisticated cleaning products than attacking them once they've been in place for a few days—water and a damp microfiber cloth will usually be adequate.

However, we recognize reality—most owners wait until the bug buildup becomes bothersome and then start the tiring exercise in elbow grease. We wanted to find out if there is a way to make the task easier for procrastinators. Spoiler alert: We found that there's no magic bullet, however, Wash Wax All and the Aero Scrubber Pad proved a remarkably effective combination—plus, access to water is not needed.

TEST SET UP

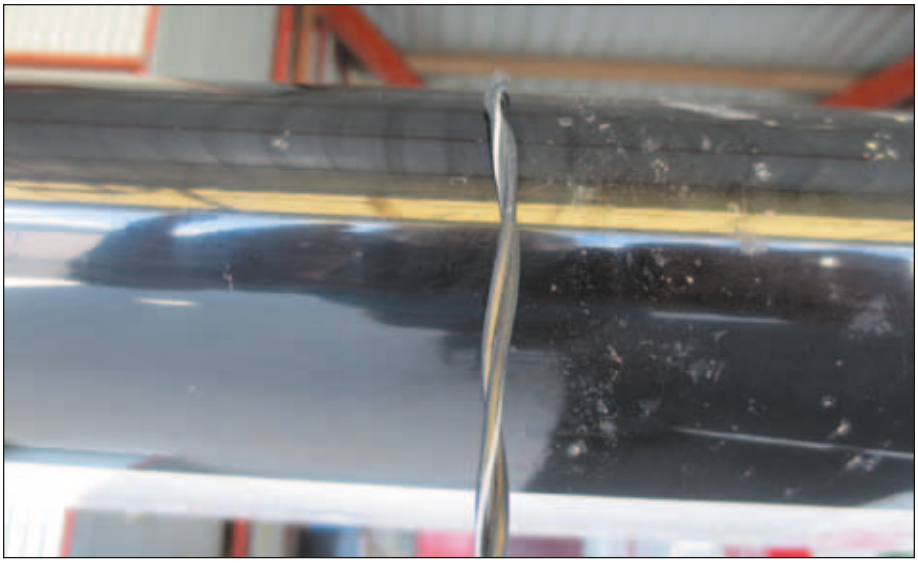
We started with a list of over 20 products (and techniques) and winnowed it down to a reasonable number to test based on product labels (no abrasives allowed) and recommendations of aircraft owners, mechanics and aircraft detailers.

We settled on plain water, Flight Jacket, Wash Wax All, Protect All and Aero Scrubber Pads. We also bought Rejex—not a cleaner, but a reactive chemical coating that its packaging claims creates a protective polymer finish—and started what will be a several-month exercise in seeing if it makes subsequent bug removal easier.

Based on recommendations of professional aircraft detailers, we also chose not to use rags, towels or paper towels with any of the cleaners—we stuck with microfiber towels and the aircraft-specific cleaning pad. Perhaps we were too conservative, but being gentle with aging aircraft seems sensible to us. Aircraft detailing and concerns about protecting aircraft paint was covered in the April 2013 issue of *Aviation Consumer*.

We used an airplane that had been washed four months earlier. Bugs had been cleaned off periodically, but no new wax or protectant had been applied to the leading edges. It had been flown at varying altitudes through the Mountain West and Midwest for over 30 hours and more than a month since bug splat had been last attacked.

Rear, Rejex, Flight Jacket, water, Protect All, Wash Wax All. Front, Aero Scrubber Pad.



Wing leading edge after one treatment with Wash Wax All and an Aero Scrubber Pad (black paint, not a de-icer boot).

WATER

Some aircraft owners told us that plain water and a wet cloth combined with elbow grease will remove bugs from leading edges. We used a spray bottle to soak the bugs and then waited several minutes before we tried to wipe the bugs off. Few carcasses were removed, despite repeated application of water and lots of rubbing.

PROTECT ALL

At $18.75 from Amazon.com, Protect All All-Surface Cleaner came recommended by aircraft owners. The label said its dry wipe application will clean, polish, wax, treat and create a super slick anti-static finish for easier and less frequent cleaning. We noted that it contains Carnauba wax, popular for cars but frowned on in the aircraft world as automotive waxes do not hold up well in flight. It potentially can cause static build-up that Mike Pride of Leading Edge Aviation in Dallas, Texas, said can cause interference with flight instruments.

The instructions called for application to a small area with a dry cloth to be used to spread the product evenly. Next, a second dry cloth is used to wipe the area dry. In our test, Protect All was only slightly more effective at removing dried bugs than water. Protect All applied to a clean leading edge may act as a protectant and make it easier to subsequently remove bugs, but it didn't live up to its claim as a cleaner. Also, as a protectant, technology has moved beyond Carnauba wax—reactive polymer coatings, such as used in Rejex, are favored by detailers.

FLIGHT JACKET

AeroShell has a line of six what it refers to as "appearance products" under the Flight Jacket name. We were guided to the Oil and Exhaust Remover ($10.98 from Skygeek.com) by enthusiastic comments from aircraft owners and labeling that promised it was non-abrasive.

The instructions called for spraying the product on affected areas, letting it stand one to two minutes and then wiping it off with a Flight Jacket microfiber cloth. We followed the instructions except for using the generic microfiber cloths we had on hand.

Results were fair, much better than water or Protect All, but getting the dried bugs off required several treatments and a lot of rubbing.

WASH WAX ALL

Wash Wax All ($9.95 at Amazon.com), from Aero Cosmetics, is one of the company's line of aircraft cleaning and polishing products. It was the product most often mentioned favorably by aircraft owners when we discussed bug removal.

The packaging for the product included a number of clearly written pamphlets that described how to use the products effectively. One contained a section devoted to removing bugs—and called for using Wash Wax All with a microfiber cloth or an Aero Cosmetics Aero Scrubber Pad ($19.95 for two at Sportys.com).

The recommended procedure is to spray the area and let it soak five to 10 minutes. Next respray an area "that can be comfortably cleaned" and use a microfiber cloth or Aero Scrubber Pad to "break up bugs," then wipe the area dry with another microfiber cloth before the Wash Wax All dries on its own.

Following the instructions, we had to wipe off the excess product that ran aft of the leading edge of the wing or tail before it dried—a minor matter. Using a microfiber cloth to break up the bugs and another to dry the area gave about the same results as the AeroShell Flight Jacket product—good, but needing more than one application.

Using the Aero Scrubber Pad—advertised as "soft, non-scratching and reusable"—gave us results that impressed us. The dried-on bugs that had required repeated applications to remove came off almost completely on the first go around. Only a few bug splats required another spray-and-wipe cycle to break up and eradicate.

We were so surprised at the effectiveness of the Aero Scrubber Pad over the microfiber cloth that we tried it with the Flight Jacket and Protect All products as well as plain water, thinking it might improve their games. It did—but not to the level of using it with Wash Wax All.

CONCLUSION

Our recommendation for an effective dried bug removal treatment is Wash Wax All with an Aero Scrubber Pad. We note that Aero Products says to keep the pads clean, wash them after use and store them in a sealed container—and to stop using a pad if it touches the ground.

We like the low price of Wash Wax All and the effectiveness of the Aero Scrubber Pad. While the best way to clean off bugs is to do it after each flight, keeping a couple of Aero Scrubber Pads in a zipper lock bag and a spray bottle of Wash Wax All in the hangar or the back of the airplane will make the job of cleaning easier for the procrastinators.

Lockheed Martin ACAS: Flight Services Datalink

Lockheed Martin Flight Services is upgrading its ACAS with inflight alert briefings via text and email messages, but data delivery options are limited.

by Larry Anglisano

If XM Broadcast and ADS-B FIS-B weather isn't enough (or if both sources fail, as we experienced on a recent flight) Lockheed Martin Flight Services has a new inflight alerting system that can update your weather briefing as conditions change along the route.

Lockheed's updated ACAS (Adverse Condition Alerting) datalink service uses the Iridium satellite network to deliver alert messages through portable and fixed transceivers. The data stream also accommodates two-way electronic communications for touch-of-the-button inflight PIREP submission, in addition to optimizing the search and rescue process when using portable tracking devices equipped with SOS alerting.

START WITH A BRIEFING

The newly automated ACAS messaging protocol isn't intended to be a replacement for weather briefings, although the system is smart enough to know if you've been briefed. Instead, ACAS alerts should be used to supplement and update the information you've already received in a previous briefing.

Registering for ACAS alerts is first accomplished by creating an account on the Lockheed Martin Pilot Web Portal, where you then select the Alerts sub-tab in account preferences. There's also an area to select which Iridium satellite communicator

CHECKLIST

- We're pleased that Lockheed Martin is exploring new technology.
- Electronic PIREPs are easier for the sender and combat latency issues.
- Communicators with compatible datalink capability are limited.

You'll need an Iridium satellite communicator like the $379 DeLorme inReach Explorer, upper right, or the $1795 SpiderTracks S5, lower right, to use Lockheed's SE-SAR. Lockheed's planned NextGen Briefing will include textual and graphical TAF summaries, left. An inflight internet connection will bring it to the cockpit.

Honeywell's SkyConnect system, top, and Garmin's integrated GSR56 for Cirrus Perspective, bottom, can handle ACAS text message alerts.

device the alerts should be sent to. More on that in a minute.

Alerts are sent to the cockpit using text messages (also known as Short Message Service or SMS messages), email messages, or short messages similar to SMS messages. These are transmitted via the Iridium satellite constellation directly to modem-equipped devices.

The alert messages only identify the type of adverse condition and the flight plan to which it applies. Lockheed advises that pilots still should contact Flight Services to obtain complete details for the adverse condition. However, pilots can also go to their home page on the LMFS Pilot Web Portal to view and acknowledge ACAS alerts for their flight plans without having to call a specialist.

The ACAS generates flight plan alerts for TFRs (a huge benefit, in our estimation), NOTAMs for airports or runways being closed or unsafe, AIRMETS, SIGMETs (including convective), center weather advisories, severe weather watches and warnings, and urgent PIREPs. To better filter the alerts, the adverse condition must either intersect or be within a standard 25 NM corridor of the flight plan route. Alerts are limited, for now, to VFR flight plans because according to Lockheed's Mike Glasgow, ammendments to IFR routing can affect the accuracy of the update alerts. As the system evolves, IFR plans will be included, he told us.

If the ACAS finds that a standard briefing was performed for a flight plan, only adverse conditions that occur after the briefing time can result in an alert. Once an alert is sent to the pilot, and if the pilot contacts Flight Services to obtain the details of the adverse condition, the specialist will know that the pilot received a standard briefing. In that case, if no further information is requested, the specialist will be able to provide just the details of the specific adverse condition. The key here is to cut to the chase and quickly get the additional information you need, rather than information you already know.

ENHANCED SURVEILLANCE

Surveillance-enhanced search and rescue (SE-SAR) is a capability that's currently in the system now. Users can choose to have Lockheed Flight Services to track them via an Iridium-based device via SpiderTracks, Delorme InReach, Garmin Perspective and Honeywell SkyConnect.

When you issue an emergency SOS alert, the information is immediately linked to Lockheed personnel that are monitoring the activity on a computer screen.

With SE-SAR, search and rescue protocols are initiated immediately, rather than waiting the normal 30 minutes after the proposed ETA. This potentially reduces the overall area that has to be searched because Lockheed will know the point and time of your ditching, if you were able to initiate the SOS.

Additionally, if the aircraft stops transmitting or remains on a fixed position for a certain period of time, this triggers a search and rescue effort. The SpiderTracks and inReach devices can be registered on the Lockheed Pilot Web Portal now. Additionally, Lockheed is planning a future ADS-B data interface, but it's unclear exactly what additional features it will enable.

AEROVIE PIREP

Another area that Lockheed Martin is trying streamline is pilot reporting. It recognizes that traditional pilot reporting can be delayed, due to processing times.

Through the Aeroview Pilot tablet app, you can submit PIREPs electronically to Flight Service, in addition to viewing other PIREPs, and receive PIREP alerts near your current position.

The electronic PIREP demo we saw during its unveiling at AirVenture last month seemed straightforward and efficient. The idea is to eliminate heads-down time when creating and sending the PIREP.

The Aerovie app has dedicated menu tabs for common PIREP conditions that are broken down into three major categories, including Ride, Precipitation and Icing. Simply select the tabs that best fits the current flight conditions and the data is transmitted via satellite. It's then downlinked to Lockheed Martin and goes into the system within minutes.

The Aerovie app, which is compatible with Apple iOS and Android, has other functions when interfaced with Garmin Perspective for Cirrus applications and Avidyne Entegra suites, including engine data download and flight dispatch functionality.

Lockheed is currently developing the Departure Planning Tool, which is a chart that lays out a time scale of when the weather is expected to be VFR, MVFR or IFR. Using the plotted time and condition tool, you can plan your departure appropriately.

LIMITED HARDWARE

The snag with this concept in general is there isn't a wide variety of hardware with compatible internal

continued on page 32

Lightspeed Follow-Up: Ensure a Correct Fit

The shorter headpad on the new Zulu PFX headset could be detrimental to the product's performance. Try the taller pad for improved noise cancelling.

by Larry Anglisano

In our August report, we were impressed with Lightspeed Aviation's new Zulu PFX headset, but had issues with consistent ANR performance. At press time this month, Lightspeed sent us a new headpad that improved its fit and performance, transforming the headset.

After exhaustive flight trials, we initially found enough to like to recommend the Zulu PFX as a worthy investment, particularly given the new digital technology that's behind it. Still, we favored the aging Bose A20 after a side-by-side comparison conducted in a variety of aircraft. Based on feedback from some other users, we weren't alone.

One of the nits we and others had was that the ANR performance was impaired by turning the head (or entire body) 30 to 60 degrees to either side. The resulting rumble and distortion was especially pronounced with the left earcup pointed toward the front of the airplane.

Moreover, our sense was that the Bose does better at stifling lower frequency noise. But all of that is fixed with a simple replacement of the padding that attaches to the headband.

CRITICAL FIT

A proper fit and seal around the ears is the key to solid noise-cancelling performance with any ANR model. Unfortunately, that can be difficult to achieve. Small heads, big heads, glasses, ballcaps—these are all factors that can greatly alter the performance of noise-cancelling circuitry.

In our PFX trials, we used an early production unit equipped with the standard headband padding that fits between the underside of the headband and the head. For some users (us included) the thinner padding design doesn't offer enough downward adjustment of the slider to place each earcup entirely over the critical area on the side of the head. Turns out this was the culprit that contributed to the lousy ANR performance we sometimes experienced during the evaluation. Still, it proved a valuable lesson.

While all ANR models have a fixed level of noise cancellation and audio profile, the PFX—with its software-controlled circuitry called Streaming Quiet—offers a personalized noise-cancelling signature that maps to the ears and customizes the noise cancellation. While this software can compensate to some degree, the headset still requires a proper fit.

Lightpeed's new Zulu PFX matches the Bose A20 in price, and now that we've dialed in the performance of the ANR circuitry with an easy swap of the headpad, we think it matches the Bose's ANR performance. On the other hand, whether it's more comfortable is a personal opinion, and some users we spoke with that have purchased the PFX think it is. We think it's more forward-thinking.

"The smartphone became a device that provides so much more information and benefits and continues to evolve all the time. This is what the firmware upgradability and the processing power of the Zulu PFX means to the headset category," said Lightspeed's Ed Hanson.

If you are going to invest $1100 in a headset, we think it's important to try it before you buy it. If you already bought a Zulu PFX and experience ANR problems, Lightspeed's Hanson said to call the Lightspeed customer support team and tell them you need a tall headpad, at no charge. Contact www.lightspeedaviation.com, 800-332-2421.

We swapped the PFX's stock headpad with a taller one, inset, and it tremendously improved the ANR performance. Depending on the size and shape of the head, you might sacrifice a slight amount of comfort for performance.

Robinson R44

A utilitarian and affordable four-place helicopter for the common man that's in a class of its own.

Pilots looking for a used aircraft usually have a mission in mind: Carry a specific payload over a certain distance in a minimum amount of time. And if you need to get to and from remote locations while mixing it up at nearby Big City International, you might have overlooked the helicopter.

Until the early 1990s, anyone needing a personal helicopter configured for more than two or three seats had to go the turbine route; there were no piston-powered four-passenger helicopters. That changed in late 1992 when the Robinson Helicopter Company obtained FAA certification of its R44, a four-place rotorcraft powered by a Lycoming piston engine.

While offerings from Enstrom, Schweizer, Brantley and even the venerable Bell 47 have proven popular, none of them seat more than a pilot and two passengers at most. Robinson's R44, on the other hand, takes the standard two-plus-two seating configuration of the a personal airplane and gives it a vertical takeoff and landing capability. The result is a hugely popular four-seat single—that just happens to have a rotary wing. Robinson sold 664 copies of the R44 in 2007, which was around the end of the heyday of a booming market.

> *The R44 gives vertical capability to what's essentially a four-place airplane.*

HISTORY

Frank Robinson's dream of a small, low-cost helicopter convinced him to resign from the Hughes Helicopter Company in 1973 and found the Robinson Helicopter Company (RHC).

The two-place R22 quickly became the world's top-selling civil helicopter and turned Robinson into what many think of as the "Henry Ford of helicopters."

But the R22 hasn't been without its rough spots. Although RHC didn't intend it to be one of the world's most popular trainers, that's what it soon became. The R22 was tarnished by a number of accidents, and the lightweight rotor system resulted in little inertia, increasing the likelihood of low rotor RPM, blade stalls and fuselage strikes. Also, the rotor design itself, being of the semi-rigid type, where the rotors are free to tilt with respect to the main rotor shaft, allows the blades to see-saw or flap together. Its larger brother, the R44 Raven, didn't come along until 1992, but

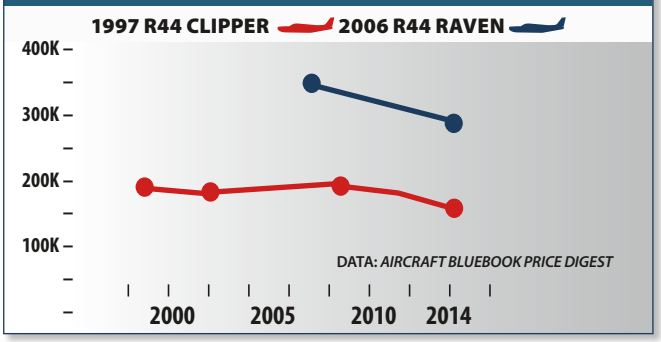
ROBINSON R44

drawings courtesy www.schemedesigners.com

ROBINSON R44 SELECT MODEL HISTORY

MODEL YEAR	ENGINE	TBO	OVERHAUL	FUEL	USEFUL LOAD	CRUISE	TYPICAL RETAIL
1997 R44 CLIPPER	LYCOMING O-540-F1B5	2200	$30,000	48.9	1000 LBS	113 KTS	±$170,000
2000 R44 RAVEN	LYCOMING O-540-F1B5	2200	$30,000	48.9	1000 LBS	113 KTS	±$200,000
2003 R44 RAVEN I	LYCOMING O-540-F1B5	2200	$30,000	48.9	1000 LBS	113 KTS	±$255,000
2006 R44 RAVEN II	LYCOMING IO-540-AE1A5	2200	$30,000	48.9	1000 LBS	113 KTS	±$295,000
2009 R44 RAVEN I/II	LYCOMING IO-540-AE1A5	2200	$30,000	48.9	1000 LBS	113 KTS	±$360,000
2012 R44 RAVEN I/II	LYCOMING IO-540-AE1A5	2200	$30,000	48.9	1000 LBS	113 KTS	±$425,000

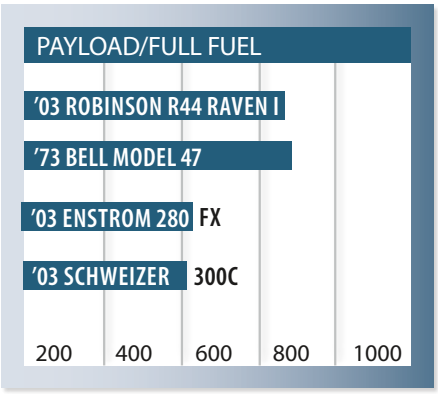
RESALE VALUES

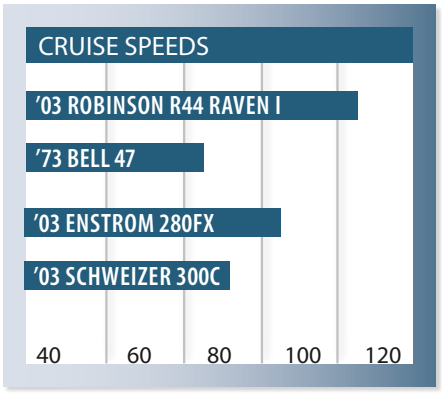


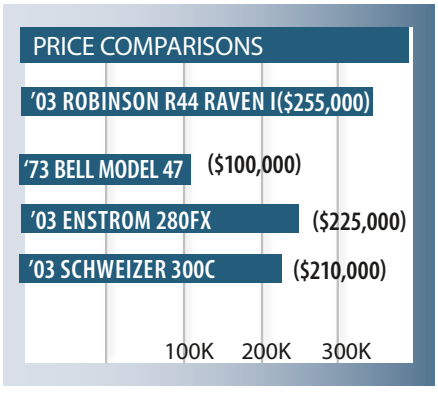
SELECT RECENT ADs

AD 97-02-15	LOW RPM WARNING THRESHOLD
AD 99-17-17	REPLACE CERTAIN YOKE ASSEMBLIES
AD 98-22-16	MAIN ROTOR BLADE INSPECTION
AD 2008-08-04	SPRAG CLUTCH REPLACEMENT
AD 2013-05-15	EMERGENCY FLOAT INFLATION VALVE REPLACEMENT

SELECT LATE-MODEL COMPARISONS







The R44's semi-rigid, low-inertia rotor, top, is supported by a tall mast. The T-handle cyclic, center, is light but pilots complain it can be bumped by clumsy passengers. Versions of the Lycoming O-540 power the R44.

it inherited some of the R22's DNA, including a heavier but still relatively lightweight semi-rigid main rotor. In the mid-1980s, RHC began developing the four-seat R44 Raven. Its FAA certification was obtained in late 1992, and deliveries began in 1993. By early 2001, more than 1000 R44 helicopters had been delivered in 50 countries, with the R44 quickly becoming more popular than the R22. Robinson billed the type as delivering "the performance of an expensive turbine helicopter at an affordable piston price." Then it offered a turbine version, the R66.

That machine retains many of the design features of the R44, including a two-blade rotor system, T-bar cyclic and an open interior cabin configuration. It's powered by Rolls-Royce RR300 300 SHP turboshaft derated to 270 SHP for takeoff and 224 SHP continuous.

PERFORMANCE

The current R44 Raven comes in two flavors. The Raven I is powered by a carbureted Lycoming O-540-F1B5 engine rated at 225 HP for a five-minute takeoff and 205 HP all other times. The fuel-injected Raven II flies with an IO-540-AE1A5 of 245 HP for five minutes and 205 HP continuous.

In addition to upscaling the R22 and tacking on two additional seats, the R44 has a hydraulic flight control system. All R44s share that system, as well as fuselage and rotor components. Both Ravens also are available in RHC's Clipper configuration, which includes fixed floats for over-water operation. When the fixed floats are installed, an 80-knot indicated airspeed never-exceed limitation is imposed.

The R44 Ravens also are available in IFR Trainer trim, which adds an artificial horizon and turn coordinator, along with a marker beacon receiver, to the standard equipment list. Meanwhile, the Raven II can be purchased in three-seat Police Helicopter and Newscopter configurations.

A new R44 Raven I carries a base list price of $320,000; a new Raven II's pricing starts at $387,000. Paying close to around $5.50 a gallon for 100LL and budgeting realistic amounts for maintenance and the 2200-hour overhaul, direct operating costs of an R44 are in the $170 per hour range.

Max gross weight for the Raven I is 2400 pounds; for the Raven II, it's 2500 pounds. The current-production Raven II is billed as weighing 1506 pounds empty, leaving a 994-pound useful load. Standard fuel capacity is 30.6 usable gallons, while auxiliary fuel totals another 18.3 usable.

Cruise speed is billed as no more than 117 knots and its no-reserve maximum range is about 400 miles, according to RHC. Maximum operating density altitude is 14,000 feet, but the FAA TC limits the R44 to no higher than 9000 feet AGL, to allow landing within five minutes in case of fire.

SAFETY

It helped keep manufacturing costs and gross weight low, but that low-inertia rotor system was an early source of problems for the Robinson fleet. Helicopters with semi-rigid rotors are vulnerable to a condition known as mast bumping, which can cause the rotor flap stops to shear the mast, resulting in loss of the main rotor. Mast bumping is normally encountered during low-G maneuvers and is not peculiar to the R22 or R44.

In fact, helicopter engineers maintain any two-blade helicopter is susceptible to mast bumping, including the ubiquitous Bell UH-1 of Vietnam and its civilian siblings. One of the keys to coping with the combination is avoiding any low-G conditions.

But that solution either wasn't readily apparent to instructors and students or didn't sink in. By 1994, the

TYPICAL INSURANCE COST EXAMPLES

R44 VALUE	PILOT TIMES	ANNUAL PREMIUM
$250,000	PRIVATE PILOT OR BETTER, 50 HOURS ROTOR, 50 IN ROBINSONS	$10,000
$500,000	PRIVATE PILOT OR BETTER, 50 HOURS ROTOR, 50 IN ROBINSONS	$17,500
$150,000	PRIVATE PILOT OR BETTER, 100 HOURS ROTOR, 100 IN ROBINSONS	$7000
$350,000	PRIVATE PILOT OR BETTER, 300 HOURS ROTOR, 300 IN ROBINSONS	$11,500
$250,000	PRIVATE PILOT OR BETTER, 300 HOURS ROTOR, 300 IN ROBINSONS	$9000
$500,000	PRIVATE PILOT OR BETTER, 300 HOURS ROTOR, 300 IN ROBINSON	$15,500

Assumes no losses for any pilot, premiums based on pleasure and business use. Liability $1,000,000 limited to $100,000 per passenger

One option available on the R44 is pop-out floats, right, for emergency water landings. The aircraft can also be equipped with amphibious floats for intentional water operations. Both options reduce payload.

R22 was the subject of three special certification reviews conducted by the FAA. The R44, the NTSB noted in that year, might have been subject to a "lack of oversight" in the design certification process, which may have contributed to one or more accidents of the still relatively new airframe. As one result of the NTSB recommendation, the R44 was added to the third and final FAA special certification review. In September 1994, the NTSB stated it considered the FAA's reaction to its recommendations acceptable.

In 1995, Special Federal Aviation Regulation (SFAR) 73 was issued against the R22 and R44, requiring minimum experience and training in excess of Part 61 requirements before performing pilot-in-command and/or flight instructor duties. Among other requirements, the SFAR mandates "awareness training" in energy management, mast bumping, low rotor RPM, low-G hazards and rotor RPM decay. An annual flight review in an R22/R44 is required before serving as PIC. Additionally and for transitioning fixed-wing pilots, the SFAR requires a person not holding a rotorcraft category and helicopter class rating to have at least 20 hours of dual instruction in a R44 before soloing it.

By most accounts, the SFAR did what it was designed to do—increase pilot awareness of the R22/R44's design differences when compared to other helicopters—and the accident rate began dropping. Today, SFAR 73 has served as a model for other safety measures, including a recent review of the Mitsubishi MU-2 series. The FAA extended the "temporary" SFAR 73's termination date to June 30, 2009.

One other item involving the R44's safety deserves mention: the T-bar cyclic control. Most helicopters have two cyclic sticks poking up from the floor in front of the pilot seats. The Robinsons have a cyclic coming up from the center of the ship with horizontal arms at the top. If the left side arm is attached (Robinsons are flown from the right seat), either pilot can apply pressure to the cyclic. A downside is that even with the left controls removed, the cyclic is close to a passenger's right leg and arm, making him or her much more likely to nudge it accidentally.

TRAINING/INSURANCE

Fixed-wing pilots have been known to describe learning to hover a helicopter as the aeronautical equivalent of trying to stand on two well-greased bowling balls stacked atop each other. Regardless, you'll need to obtain at least the minimum training required by SFAR 73 before serving as PIC in your R44. Even though adding on rotorcraft category and helicopter class privileges to your fixed-wing certificates isn't free, it should be less expensive than starting from scratch.

One training facility with which we're familiar suggests budgeting around $19,000 to add on private R44 privileges to an existing fixed-wing certificate. That presumes all rotorcraft time will be in the R44; some cost savings can be found by using the less-expensive R22.

COMPETITION

As we noted at the top, the R44 really has no competition from other four-seat piston-powered helicopters. Still, offerings from Bell, Enstrom, Schweizer and Brantley do compete in the used market. Only the Enstrom and Schweizer remain in production, however, and—except for Bell's 47—there simply weren't that many of them produced.

Reinforcing the concept that the R44 is really in a class by itself is the fact none of the other piston-powered

R44 helicopters can serve a broad mission profile, from personal transportation, law enforcement, sightseeing missions and even training, although the R22, middle, is more logical for initial training. Break an R44—or any helicopter—and get ready for big repair invoices, bottom.

helicopters can seat four; they only accommodate three and do it by placing everyone on the same bench-style seat. Except for the R44, one must keep climbing the market ladder until reaching the Bell 206 and the Hughes 500—both of which are turbine-powered. As mentioned, there's also the R66—the turbine-powered Robinson.

MAINTENANCE/COSTS

Operators report that R44s require minimal service between 100-hour inspections and parts are reasonably priced; one likened the pricing to automobile parts. Unlike many other aircraft manufacturers, RHC makes its parts price list available on its website. RHC strongly recommends overhauling the engine and major items like gearboxes, rotor blades, bearings and the like at 2200 hours, or 12 years. In fact, the milestone is mandatory for commercial operators. While voluntary for privately operated R44s, it's a good idea since, as one operator notes, most of the important parts are largely used up and due for replacement by then, anyway.

Three choices exist to perform the overhaul: Fly the R44 to Robinson's factory where company workers will make it like new on the production assembly line, including its cosmetics; buy an overhaul kit and have a third party perform the labor; or have your local mechanic do the work using the same overhaul kit.

The list of components in the factory overhaul kits is long; letting the factory do the work means even items not in the kit will be replaced if needed and the ship's paint, interior, placards and the like will be brought back to as-new condition.

Robinson breaks costs into three main areas, including a Lycoming factory remanufactured engine at $35,000, the overhaul parts kit at $126,000 and labor (240 man-hours at

$90) for $21,600. Grand total, according to Robinson's 2014 estimate of operating costs: $182,600, which works out to $83.00 per hour for a maintenance reserve, higher if you get to 12 years without reaching 2200 hours. That's for the basic helicopter, without unscheduled maintenance issues, nor any consideration for avionics.

Figure in fuel at $6.10 and 15 GPH ($91.50), oil and periodic inspections at $16 an hour and you have the basics for determining direct operating costs. Add it all together and it comes to $213.67 hourly operating costs.

One question you might ask would be, how does RHC get 2200 hours out of a Lycoming O-540 before overhauling it, when most other applications of this engine reach TBO at either 1800 or 2000 hours? The answer is in the footnotes accompanying Lycoming's service instruction setting TBO, which allows an extra 200 hours for the two engine types used in the R44 I and II when "an engine is being used in frequent type service and accumulates 40 hours or more per month, and has been so operated consistently since being placed in service."

A result of complying with the 2200 hours/12-year overhaul requirement is flying what is basically a brand-new helicopter every time that milestone rolls around. Another is that resale value is maintained—most prospective buyers will want to use the R44 at least some of the time for commercial purposes and will have to comply with the overhaul requirements, anyway. Too, complying with—and documenting—the overhaul and other factory maintenance recommendations eliminates problems when selling your R44. The downside is your wallet is a lot lighter.

MODS/TYPE CLUB

The mods available for the R44 make it better suited for the kind of special mission at which helicopters excel. Examples include external storage pods from New Zealand manufacturer Helipod, a cargo hook system available from various vendors, aftermarket emergency float kits and "bear paws"—flat-plate metal attachments designed to prevent the skids from sinking into soft ground. Also offered by various vendors and STC holders are mods like engine monitors and Precise Flight's Pulselite system. Available for the carbureted R44 Raven I is

HELICOPTER INSURANCE: TIMES FIVE

by: Sutton James Insurance Agency

Fixed-wing pilots who get the helicopter bug are struck by how much more everything costs, and insurance is no exception. Insurance for non-commercially used helicopters typically costs between three and five times as much as it would for an airplane with similar seating, value and pilot experience.

Another difference when making the switch to fling-wings is the size of the deductibles, which can often amount to five percent or even 10 percent of the value of the helicopter.

Insurance is likely to be your largest fixed cost, so it pays to ask questions up front. Be sure to secure accurate costs early in the decision making process. We recommend using an aviation broker who has experience in this area.

There was a time when finding insurance for a Robinson helicopter was difficult, but thanks in part to a softening insurance market, insurance is now readily available from a variety of sources.

Pathfinder Indemnity has been insuring Robinson helicopters since 1986. Chartered in the Bahamas, it is not for everybody. Pathfinder typically has lower costs than other insurers, but has some downsides. You deal with the company directly, rather than through a broker. If you have a legal disagreement with Pathfinder, you may have to pursue it in a foreign jurisdiction. And unlike most liability policies, the cost of defense is included in the overall limit of coverage. Pathfinder also reduces what it will pay to replace the helicopter for each hour it has been in service since its last overhaul. More significant, Pathfinder policies include Robinson Helicopter Company as an additional insured on every policy, so policyholders are forced to share their liability protection with the manufacturer.

The Robinson Helicopter Insurance Program is not affiliated with the factory and offers a safety-based program for R22 and R44. The program is underwritten by Starr Aviation and administered by Sutton James, Inc. in Hartford, Connecticut. Participants in the program undergo an annual safety audit and recurrent training in return for reduced rates and lower deductibles. The program also accepts the factory safety course.

As with most types of aircraft insurance, the principal drivers are the cost of the helicopter, the experience of the pilot and the mission. Whichever insurance route you choose, the cost will generally fall as you accumulate experience.

Apart from these two specialty sources, which will typically provide the most competitive premiums, there are a number of aviation insurers who will provide coverage for Robinson helicopters. These companies are accessed through brokers. While it may cost more, it may be the only way to obtain a smooth limit of liability, lower deducible or coverage for a particularly dicey kind of work. And thanks to a historically soft aviation insurance market, you might find the best deal with one of these companies, especially when you weigh in your risk tolerance.

Representative approximate cost indications to insure an R44 through the Robinson Helicopter Insurance Program are shown in the chart on page 26 for a range of values and pilot experience levels.

R44 WRECKS: LOSS OF CONTROL

In the bad old days, it always seemed that helicopter accident reports began with the phrase, "Pilot heard loud bang, shortly thereafter control was lost," because something critical broke.

The good news is that our review of the 100 most recent accidents involving Robinson R44s uncovered only two crashes where the machine flung parts—and both were due to maintenance errors, not design. In one, the NTSB documented that the mechanic didn't get all the pitch link to swash plate hardware secured because the owner distracted him with constant demands to hurry.

The other news is that there were a lot of accidents directly related to skill levels of or poor judgment on the part of pilots and not, in our opinion, attributable to the design of the helicopter. They were: loss of control in gusty winds, loss of rotor RPM because the pilot tried to get performance out of the Robbie that wasn't built in by trying to fly at high density altitudes or while heavy—or both—as well as the old faithful helicopter killer, which is flying low and hitting something.

What we did see that is arguably design related was a number of post-crash fires in low-speed or rollover impacts; something not common in helicopters since the 1970s. The original design had aluminum tanks on either side of the rotor mast—they are now rubber bladders and a 2010 Service Bulletin calls for retrofit of older models.

High density altitudes bit a number of R44 pilots. A landing attempt in gusty winds at a density altitude of 10,059 feet resulted in loss of rotor RPM and an attempted run-on landing that flipped the helo. Another pilot tried to circle a mountain peak at a 13,918-foot density altitude. When he got to the downwind side, he got into a downdraft that he couldn't escape and eventually hit the ground.

More than one Robbie pilot loaded his helo over gross and found that it would fly in ground effect but not out of it—rotor RPM promptly decayed and the subsequent attempt to land resulted in a helicopter that was in pieces.

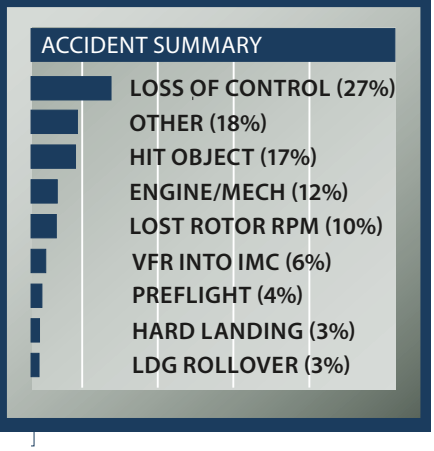
About half of the loss of control accidents were during takeoff in gusty wind conditions, often with a tailwind.

Seventeen accidents involved R44 pilots who were flying low—often very low—and hit an object. One "sight-seeing flight" was at only 65 feet AGL when it hit an obstruction. A pilot flying just above the trees on a job to "dry out" an orchard hit a wire. Power lines snatched several R44s from the air. One pilot who had scouted out a landing site very carefully touched down safely. He then decided to hover taxi a few hundred yards to what he suddenly decided was a better spot and hit power lines on the way.

Six pilots flew VFR into IMC—an almost universally fatal event. One, however, survived taking off and running into fog, attempting to continue climbing and running into a tree.

One pilot took off from underneath a canopy covering a fueling area, hit it and crashed.

Bottom line: judgment matters—a rancher saw a bull stuck in some plastic. He unsuccessfully attempted to herd the bull toward ranch hands with his R44. He then tried to "elevate" the bull with one skid. The helicopter rolled over and destroyed itself and the bull.



an STC allowing automotive gasoline. We're not aware of a formal type club for the Robinson fleet, but the Robinson Helicopter Owners Group (RHOG) comes close, at www.robinsonhelicopters.org.

OWNER COMMENTS

Robinson's R44 is probably the best helicopter in the world for personal ownership; it also might be the best helicopter for primary training. I'm heavily involved in R44 ownerships, which are used for transition training/time building and for personal transportation.

When comparing the two models, the Raven II offers another 50 pounds of payload, but most owners use that up with options such as air conditioning and pop-out floats. Baggage is stored underneath the seats. The crushability of the seats is a primary protection in a crash. People have broken their backs in accidents that they might have walked away from if they had simply avoided putting non-crushable items under the seats. If you're going to carry the wheels, for example, keep one under each seat and make sure that the steel handle is flat.

I find the R44 more comfortable than my Cirrus SR20 airplane and more comfortable than the seats in a lot of light airplanes. Heat is ample and uniformly distributed throughout the cabin. The fresh air supply is good, but noisy. We try to use the little vent windows cut into the doors and, if that isn't enough, removing a door. The noise of the fresh air system is audible over the noise of an open door.

If you put in a control input, the helicopter responds immediately and dramatically. A heavier helicopter responds more gradually. The R44 is like a sports sedan; the big turbine helicopters are like trucks. The piston engine provides instant power changes without the spool-up time of a turbine.

Aside from oil changes, nothing in the R44 requires service between 100-hour inspections. Direct operating costs are approximately $170 per hour.

At 500 hours, our Raven I began to make some ugly noises when we attempted to start it. At the 100-hour inspection, the mechanics found broken teeth on the ring gear (engine side) and on the B&C brand starter. The most likely explanation is that someone tried to start the engine and it failed to catch, and then they

tried again without waiting long enough for the starter motor to stop spinning. My Raven I has been virtually trouble-and-maintenance free.

Our chief mechanic reports that every part ordered from Robinson has been shipped the same day that it was ordered, a significant contributor to the high availability that we have had during 750 hours of operation. Parts are reasonably priced, similar to what you'd expect to pay for car parts.

Unlike other brands of helicopters, the R44 has one big time-in-service limit: 2200 hours or 12 years. When you reach that point, the ship must be overhauled. You can send it back to the factory or you can buy an overhaul kit and have your mechanic do the work. The latter is less expensive, but the ship won't as nice cosmetically.

Problems with two factory-new R44 Raven I IFR trainers that we purchased involved downtime. One encountered a bird, resulting in a bird fatality and a damaged rotor blade. The flight school sat on the useless helicopter for three months before Robinson was able to deliver a replacement main rotor blade.

Once during the ferry flight of a 2008 R44 Raven I IFR Trainer, the steam gauge attitude indicator failed. Robinson wanted us to pull the old attitude indicator from the ship, placard everything inop, fax them the next day to remind them to look at the old one and call them the day after that as an additional reminder. Our flight school's head of maintenance noted, "Any other aircraft company would have overnighted us a new one and taken the old one back." As a result, we lost weeks of revenue because we couldn't teach any instrument students.

The R44's long range and practicality for cross-country trips make the T-bar cyclic perhaps more dangerous than in the R22. On a long trip, people get bored. They start talking. When the non-flying person is talking, he or she is likely to be gesturing, possibly whacking the T-bar or the cyclic tube itself.

If the flying pilot doesn't have a firm grip on the controls, there is a possibility of the cyclic being pushed full forward, which might lead to a low-G situation, an improper full left cyclic input and mast bumping. I have encountered high-time Robinson pilots who've been scared by accidental knocks to the T-bar and who wish the R44 had conventional cyclics.

I fly the R44 while wearing foam earplugs and a noise-cancelling headset. The speakers in a Bose headset cannot handle the full power of an aviation radio. So if you crank up the volume on your radio to hear it through the earplugs, you'll blow out the speakers in the Bose headsets. Bose headsets, though comfortable, are not very rugged and I have often seen students with the Bose headsets have to jiggle the connectors to establish communication with ATC.

Things on my wish list include a rev limiter to prevent expensive student-induced engine overspeeds, a display of engine power percentage, rather than manifold pressure, a lightweight glass cockpit for instrument training and something to block the overhead sun from heating up the cabin.

So far, the R44 holds its value remarkably well. The asking price for a used ship is hardly different than taking the new price and subtracting the number of hours times a reasonable overhaul reserve of $83 per hour.

Philip Greenspun
Cambridge, Massachusetts

I've owned both the two-seat R22 and four-seat R44 and can say with certainty that there's little in common between the two.

One major observation that I've made is that the R44 offers a much better ride in winds and turbulence. That's likely because the R44 is heavier and subsequently has a more solid feel, especially for passengers.

My insurance costs on the R44 are a bit higher than what I pay for my twin Cessna. I'm a 4000-hour instrument-rated pilot with over 1500 hours in helicopters (including military operations) and my premium is just shy of $9000.

While I've considered stepping up to the R66, I'm not sure I'm ready to burn Jet A. Quite frankly, the R44 is more helicopter that I need for my mission.

Jonathan Butler
via email

Editor's note: Special thanks to Phil Greenspun for his detailed assistance on this Used Aircraft Guide installment, and to the staff at Sutton James Insurance in Hartford, Connecticut, for providing the insurance information.

The Aviation Consumer

Lockheed ACAS

(continued from page 22)

modems that can send and receive the data.

As we go to press, the Honeywell Sky Connect and Garmin Iridium satellite transceivers are fully functional with electronic PIREP submission and also offer cabin voice and data (including texting), in addition to flight tracking capability. Delorme's inReach and SpiderTracks—with an accompanying tablet app to display the text alerts—are affordable option for lower budgets.

Keep in mind that Iridium data costs will apply to any of these functions. As an example, SpiderTracks has monthly contract plans for as little as $15 per month for low usage and as high as $85 per month for high usage, in addition to charges for data usage and position reports.

Lockheed's electronic ACAS interface has enough steam to interest major tablet app manufacturers.

"We have worked closely with Lockheed and I think they, amongst all the providers of flight plan filing services, are doing a good job of driving innovation, which is why we continue to work with them. I think anything (we and the industry as a whole) can do to raise the awareness of inflight weather or flight threats is a no-brainer," said ForeFlight co-founder Tyson Weihs.

Lockheed Martin is working with several equipment manufacturers to bring additional datalink devices to its electronic interface. We'll look at these and other cabin connectivity options as they evolve. Contact www.lockheedmartin.com.

Great Lakes

(continued from page 13)

The trim system is Piper Cub style, with a jackscrew adjusting the horizontal fin's angle of attack. But the trim control couldn't be simpler. It's simply a cord running the length of both cockpits on the left side. Pull it forward for nose down, back for nose up; simple, direct and easy.

This isn't an airplane meant for long cross-country flights. At 65 percent power, it cruises at 115 MPH true (98 knots) burning 8.7 GPH at 5000 feet. Plan for 9 gallons and endurance is about three hours to dry tanks. With reserve, call that 250 nautical miles in still air. With a headwind, call it a long day.

If there's anything surprising about the Great Lakes, it's how easy it is to land and look good doing it. Because visibility forward is so good, there's no need to wrack it into a fast forward slip, as with the Pitts, and the approach speed is a relatively placid 75 MPH. Many older taildraggers (and most new ones) have steel spring or bungee-type gear and are ever cocked for bouncing if landed too fast. Uniquely, the 2T has oleo struts—with improved seals in the redesigned airplane—which soak up high rates and make a mediocre pilot look like the reincarnation of Tex Rankin. We landed the 2T in a 27-knot wind 40 degrees off the runway alignment and had no trouble at all.

CONCLUSION

Who's the buyer for the 2T? In our view, it might find some flight school customers but we suspect moneyed biplane aficionados may be the core market. Recall that Bowers was introduced to the Great Lakes by a customer who owned both it and one of his Wacos. There's sufficient wealth out there among buyers who can afford to write a check for a $245,000 new airplane.

For an owner interested in moderately challenging aerobatics in an airplane with exceptional ramp appeal, the 2T might be an attractive alternative to the hair-on-fire ethos of the Pitts line. It's certainly not quite the performer that the Pitts is, but it's easier to fly and absolutely easier to land. It may also be more insurable for a low-time taildragger pilot. Just don't expect it to be a practical traveling machine unless you do that solo and not on a schedule. For more, see www.wacoaircraft.com.

FEEDBACK WANTED

CESSNA 310

For the December 2014 issue of *Aviation Consumer*, our Used Aircraft Guide will be on the Cessna 310 series, the respected and load-hauling piston twin. We want to know what it's like to own these planes, how much they cost to operate, maintain and insure and what they're like to fly. If you'd like your airplane to appear in the magazine, send us any photographs you'd care to share. We accept digital photos e-mailed to the address below. We welcome information on mods, support organizations or any other pertinent comments. Please send correspondence on the Cessna 310 by October 1, 2014, to:

Aviation Consumer
e-mail at:
ConsumerEditor@hotmail.com