March 2020
Volume LII
Number 3

The consumer resource for pilots and aircraft owners

The Aviation Consumer®

Classics And Warbirds:

Shopping and ownership tips to bank on ... page 12

Prop shop floor tour … page 4

A turboprop with an e-copilot … page 17

There's a transponder in that … page 21

The Aviation Consumer

EDITOR
Larry Anglisano

SENIOR EDITOR
Rick Durden

CONTRIBUTING EDITORS
Marc Cook
Paul Millner

EDITOR AT LARGE
Paul Bertorelli

COPY EDITOR
Jennifer Whitley

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

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, 535 Connecticut Avenue, Norwalk, CT 06854-1713. 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. 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

SO LONG, VHF NAV

The ILS approach hardware at Houston Hobby International pictured below is likely planted in the turf for the long term. Still, there's a definite trend that points to an airspace based primarily on space-based navigation. As the avionics retrofit market booms along there has been lots of speculation about the future of ground-based navigation, including VOR and ILS systems. For owners looking to equip the aircraft for years to come, that's muddying the buying decision. And that's made more difficult with recent primary nav equipment based entirely on GPS, including Garmin's new line of retrofit navigators. These navigators (the GPS 175, GNC 355 and GNX 375) don't have VOR or ILS receivers, and shops tells me they are brisk sellers because they can shave thousands from the price of a retrofit, compared to going with Garmin's VHF nav-equipped GTN navigators. Based on recent discussions I've had with buyers, sacrificing the ability to fly an ILS (or navigate with VORs) was either an easy decision or a tough one. Ultimately it comes down to where and how you fly. Dollar savings is the big picture, not only for aircraft owners freshening up old panels, but for the FAA maintaining an old infrastructure of ground-based navaids.

Flash back to somewhere around 2005 when the FAA decommissioned close to 300 NDB stations, and nearly 500 procedures. This resulted in an approximate $8 million per-year savings, rather than feeding the ancient equipment that was far past the service life. The ADF receivers in the fleet of aircraft weren't getting any younger, or easier for shops to repair, either. If you've dealt with repairing a failed King KR85 or KR86, to name two popular boat anchors, you get it. Yanking the ADF receiver from the panel (and the sense antennas from the airframe) made room for GPS gear. Today there's a similar trend brewing with other ground-based nav systems, including VORs, and the FAA has a focused plan to simply make them disappear.

Phase 1 of the FAA's MON program (VOR minimum operating network) will be completed later this year and nearly one-third of the nation's VORs will be decommissioned. After that, the plan is to scrap VORs at a rate of almost one a week. It's said that over 300 VOR signals will be history by the year 2025. All of this got me thinking about the ILS—the global standard instrument approach first deployed in the late 1930s. Today there are over 1500 Cat I ILS approaches in service and despite the widespread use of precision GPS approach procedures, they may be the approaches of choice for jet ops at big-city airfields. Still, the number of LPV approaches is nearing 4500 since they first appeared in 2003. But there's a threat to the ILS network evident by the 1700 localizer-only procedures on the cutting block. Like VORs and NDBs, this equipment isn't getting any younger because the majority of transmitters are beyond the 20-year service life. And by now we all know the benefits of a precision GPS approach compared to an ILS, especially at smaller airfields and in remote areas, while the FAA fully understands the LPV's software-based cost benefit compared to adding and maintaining ground-based ILS equipment. Yes, the FAA is fixing broken ILS systems, but it certainly isn't adding any new ones.

Operationally, software-driven precision GPS approaches offer more local flexibility because they can actively be used on both ends of a runway. That's often not the case with ILS approaches, which can't be used simultaneously because of interference issues. And speaking of interference, WAAS GPS antenna installations aren't exactly without challenges, especially on small airframes, but installation is far easier than VHF ILS antennas. Even during an otherwise modern avionics upgrade you'll likely be paying for the hassles that tag along with VHF navigation antennas. It's one of those hidden costs that surface when the aircraft hits the shop floor.

So if you struggle with the decision of whether or not to ditch VHF nav capability during the next avionics upgrade, the FAA's MON program might make the decision easier. Hit us up on Facebook and describe your upgrade strategy. We're preparing an avionics survey report.—*Larry Anglisano*

MORE ON THE BONANZA

Nice report on the used A36 Bonanza in the February 2020 *Aviation Consumer* Used Aircraft Guide. Everything you said I thought was spot on. I have a few additional comments from our ownership experiences since the last update.

We recently sold our A36 for one reason—space. Our family simply outgrew the A36's capacity. This was the same reason we sold the A35 back in 2013. We routinely fly five and six people and we had resorted to vacuum-packing our luggage on a few occasions to get everything to fit. I installed the D'Shannon tip tanks to help with additional lift. After that, the only thing we could have done was the extended baggage area and engine/prop upgrades.

In the end, for our typical mission and given the cost of needed upgrades, replacing the A36 with a B58 Baron was the better option. Curiously, we sold the Bonanza for more than we paid, which strikes me as a good omen.

The tip tanks netted us roughly 1315 pounds of useful load against a 3780-pound GTOW. It was nice being able to have that flexibility, and 114 gallons of available fuel gave her a no-wind range of over 1350 nautical miles, but at a cost. With the IO-520 and a two-blade prop, the airplane really labored to climb at weights above the original GTOW of 3600 pounds. I installed D'Shannon's lower cowling running board kit at the same time to reduce cooling drag through the engine bay and it appeared to help. I saw no cruise speed reduction from the tip tanks (below 3600 pounds). In the nearly seven years and 500 hours we owned our 36, it failed to make a flight only once, and that was just a clogged fuel injector.

Our annuals typically ran in the $2000 to $2500 range, and insurance was around $1600 last year. I didn't find part costs to be prohibitive, though admittedly because of its reliability I rarely had to buy only OEM parts.

As with all Bonanza variants, the A36 is such a great aircraft. There is still nothing else on the market that matches its overall capabilities and performance. That's truly remarkable given that today's CAD-based birds can't best a basic design that was drawn up over 70 years ago with slide rules. Now we have a B58 Baron and to my astonishment, it's even better than the Bonanza.

Chris Nichols
via email

DITCHING THE VOR

I'm a longtime *Aviation Consumer* reader, a former USAF navigator and current CFII/corporate pilot. I found your recent coverage on ditching VOR navs interesting because I am troubled by the military's large-scale outages despite its charter to keep the system available for other users. As a Sequoia Falco owner I would love to see a new article on dual/triple receivers using Glonass/Galileo backup, at least available for use on our navigation apps like ForeFlight.

Do you know if the Dual Electronics portable antenna with Glonass would work without the U.S. GPS system?

I'm wanting to remove my VOR systems, but need panel avionics or a ForeFlight-compatible antenna/position source to do so.

Craig Schwab
via email

We asked Dual Electronics if its WAAS/Glonass aviation receivers, including the XGPS160 SkyPro GPS, will work entirely as a Glonass receiver and they said it will not. It requires a valid GPS signal for the Glonass receiver to work.

CESSNA 182 LANDING GEAR

In the used Cessna 182 report in the May 2019 *Aviation Consumer* you stated that the 1970 182N model introduced the tubular main landing gear from the prior model's flat spring gear. That's not correct. The 182N model had the flat spring gear and the 1972 182P model was introduced with the tubular main gear with a weight increase.

David Welch
via email

TRANSPONDER SAVINGS

Your budget transponder roundup in the February issue was timely as I needed one for my Glasair. I ended up going with the Sandia STX 165 because as you pointed out, it has a built-in encoder—that's not the case with Garmin's offering. It saved me nearly $1000 total during the install. That's not chump change—good call!

Steve Linden
via email

On The Cover: **That's a beautiful 1920s-era Travel Air 4000 doing what it does best. Making the plunge into the world of classic, antique or warbird ownership is not for the uninformed or unprepared. We help set you off on the right course with our ownership and buyer's guide article that begins on page 12.**

CONTACT US

Editorial Office
860-614-1987 (EDITORIAL ONLY)
Email: consumereditor@hotmail.com

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

Online Customer Service:
www.aviationconsumer.com/cs

Used Aircraft Guides:
203-857-3100
Email: customer_service@belvoir.com

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

Propeller Overhauls: Neglect Shortens TBO

And it could be detrimental to safety. A quality overhaul is a complex, multi-step process that gives a propeller a new lease on life.

by Larry Anglisano

It's bound to happen. Your airplane hits the shop for an annual inspection and all seems to be going well until that dreaded call from the mechanic, who says the propeller (or propellers, if it's a twin) needs to get shipped to a propeller shop for overhaul.

But what exactly happens to that propeller once it hits the shop is a mystery of sorts, as propeller maintenance is specialty work. To unravel the mystery I spent some time at Sensenich Propeller Services in Georgia, one of the country's oldest and highest-volume propeller shops. Here's a field report.

THINK INSIDE THE TBO

Sensenich Propeller Services is an FAA Repair Station with over 40 years' experience servicing props, and the company was spun off the original Litiz, Pennsylvania-based prop maker Sensenich Brothers Propeller to support the props in service.

Today the company has two locations including the Lititz, Pennsylvania, shop and the one in Gainesville, Georgia. Sensenich works with everything from fixed-pitch to turbo propellers (when we visited it had a huge supply of King Air props) from McCauley, Hartzell, Sensenich and composite MT-Propeller models. It also works with Woodward/Ontic, Dowty and Hamilton Standard governors.

Dan Landin, the shop's general manager, believes the propeller—which has manufacturer recommended TBO and maintenance intervals (typically five years and 1000 to 2000 flight hours)—is the most neglected accessory on the aircraft. As you'd expect, corrosion inside the hub is the enemy and as he noted, once a prop comes through his doors it's often too late to salvage without doing a complete overhaul. In other cases, a repair and reseal can be accomplished.

A tech at the assembly station puts the finishing touches on a newly overhauled McCauley three-blade propeller.

CHECKLIST

- Propellers generally have long TBOs, but only if they're maintained along the way.
- Overhauls can be a good opportunity to re-pitch fixed-pitch props to tweak performance.
- Corrosion, harsh conditions and lack of periodic maintenance substantially shorten a propeller's life.

"It's internal corrosion from moisture and condensation getting inside the hub. Unfortunately if you wait until there are problems, it's too late for a basic repair," Landin said. The overhaul process (done right) is extensive and time consuming, as I found out during my visit.

IN-THE-DOOR TESTING

A sizable expense that tags along with major prop work is actually getting it to the shop. The props are generally shipped in large wooden crates at a cost that can top $600. Sensenich offers a pickup and delivery service that covers the East Coast and into Texas at fees that range from $50 to $250.

Once the prop is removed from the crate the stringent paperwork chase begins and it undergoes a preliminary inspection, which includes verifying the propeller model, serial number and its condition, including any hidden damage. The props I saw varied in condition. Many were slinging oil, some had obvious signs of corrosion and many had blade damage. Ugly.

The next step is at the disassembly station where the techs remove any external components including de-icing boots. This process is also an opportunity to spot other imperfections that weren't caught during the initial inspection. The

next stop is the non-destructive testing (NDT) station. Here the propeller is inspected for cracks, damage, corrosion and any imperfections in the metal. All aluminum parts are inspected, and steel parts are submerged in dye penetrant liquid, rinsed, heated to dry and then inspected under a black light for further signs of cracks or stress.

Once deemed structurally sound, it's time to measure the various components' specs, including putting a close eye and a micrometer to the prop's piston rod to check the outside diameter for tolerance and damage. All measurements are recorded on the propeller's work order. Any component that's found to be outside of tolerance or damaged is red-tagged and scrapped so it can never be returned to service.

Many of the in-tolerance steel components are sent for a plating process. This is a sacrificial nickel-cadmium metal coating in hopes of preserving it from corrosion until the next TBO. It's common to find corrosion and wear on a prop's bearing races. The bearing arrangement circumferentially surrounds and engages with a section of the prop blade. The outer race assembly has roller bearings and the inner assembly has angular contact bearings. These have reconditioning limits and if they're met, the tech makes it so.

While the hub components are at the NDT station, the propeller blades are over at the blade conformance station. This is where the blade is precisely measured to make sure it's still within original manufacturer's tolerances. The tech does a leading-edge and face (back area of the propeller) alignment check, while measuring the blade's width and thickness with a micrometer. In general, we're told a blade can go through two overhauls in its life and remain within tolerance. There's a reason for that—evident by the next step in the overhaul.

SHAVE THE BLADE

Once the conformity check is completed, the dye penetrant inspection is accomplished and the blade bore inspection is done, it's time to recondition the propeller blades. It's a crude but highly critical step in the overhaul that takes a specialized skill to shave the surface of the propeller blade. Done correctly, the blade will look like new. No more nicks, pits, scrapes and imperfections from those high-power taxi runs on loose surfaces.

It takes a dye penetrant inspection to find small cracks and imperfections in propeller components, middle photo, but sometimes damage is visible to the eye. The top photo is a cracked hub from a Cessna 340's prop after a wildlife strike on the runway. A prop's bearing races, bottom, are inspected for wear and corrosion.

Blade reconditioning is an art because you have to ensure the airfoil remains clean, while maintaining the original shape of the blade and the prop's tip. This is done by hand with a rotary sanding machine.

If you want to alter the pitch of your fixed-pitched propeller, now is the time to do it. Maybe you want to get off the ground more quickly, or tweak some speed in cruise. There's a mystery behind the process, and it comes down to twisting the blade to get the precise pitch for the performance you're after.

Look to the aircraft's type certificate to see if it lists multiple pitch settings. Propeller pitch is measured in inches of forward movement per one rotation of the blade. There's both a climb and a cruise pitch setting.

Sensenich has a hydraulic blade-twisting machine that was fashioned after what the factory uses to twist a blade. It essentially has two hydraulic cylinders that oppose each other. Under pressure, one cylinder goes one way and the other the opposite, which causes the blade to bend. It's a somewhat crude, tedious and precise process that starts with the tech marking a series of points (stations) on the blade, which are measured from the hub. Using a digital protractor the tech measures the angles at every station of the blade's face, comparing them with the specs from the original build. You can only alter (or bend) the fixed-pitch blade a certain amount—a couple of inches

A tech sprays a fresh coat of paint on composite prop blades in the top photo. A close-up of a metal blade in the middle photo shows erosion, and the beating propeller blades take. And that's what the tech in the bottom is fixing—skillfully reconditioning the surface of a blade with a sander, careful not to alter the blade's original shape.

in either direction, in general. Of course, blade damage from a prop strike is another story. The techs at Sensenich had some amusing but scary stories of so-called field repairs to prop blades that were involved in gear-up landings and object strikes. Everything from pilots hammering the blades back into shape (or at least they thought), to mechanics heating the blades until red hot and bending them. Don't do it. If you have a prop strike—and that includes a run-in with wildlife—don't even think about flying the airplane until a qualified tech inspects the blades.

Interestingly, Landis showed me a cracked hub from a twin Cessna that smacked a deer on the runway. After the pilot cleaned the guts from the blade there were no signs of damage or bending. Landis strongly advised against flying the airplane, which was solid advice given the size of the crack his shop found on the hub.

PAINTING AND FINAL ASSEMBLY

Before heading to the painting booth, the metal propeller blades are dipped in Alodine, also known as chromate chem film. Alodining helps the paint adhere to the blade, while also protecting the blade against corrosion. Once rinsed and dried, it's time for paint.

Propeller blades can generally be painted any color you wish and the shop has done some interesting and highly professional paint work for props used on airshow aerobatic airplanes, and also for owners who want to match the prop with the aircraft's custom paint scheme. Black and grey are the most common, and black is almost always used on the face of the blade (or the area that faces the pilots) to eliminate sun glare. The tips are striped so they're visible to ramp dwellers.

Sensenich uses Sherwin-Williams Polane T Polyurethane metal-finish enamel, a two-component low-gloss paint coating that has good durability. It's available in a wide variety of colors and has good impact and abrasion resistance.

Composite blades are first coated with spray fill to fill in small voids, pinholes and any imperfections in the composite surface of the blade. Overhauls and repairs to composite propellers, which have gained popularity in recent years, involve an even more tedious and specialized process. We'll look at composite prop care and feeding in a separate article.

Once painted, it's time for final assembly. The assembly station is where the blades and hubs come together. Blade angles are set, de-icing accessories are installed and the prop is made ready for static balancing. All the hardware is properly torqued and safety wired per manufacturer's specs.

The final stage is balancing, where the prop is put on a balance fixture and is precisely balanced in both the horizontal and vertical positions.

PROP PREFLIGHTS: SPOTTING THE DAMAGE

We're all guilty at one point or another. There's more to properly preflighting a prop than quickly running a finger along the leading edge of the blades to feel for imperfections. Moreover, if you do look closely at the prop before putting the power to it, do you really know what you're looking at?

Walking away from my visit at Sensenich Propeller Services—and walking around my community hangar and eyeballing some pretty atrocious-looking props—has opened my eyes to the level of abuse our props endure. It's ugly.

Start your preflight by grabbing hold of the spinner and make sure it's tight and isn't missing hardware. Grab the blades and make sure they don't wobble in the hub. I found just that after parking on a transient ramp for a week. I made the wise choice of not flying the airplane home because it turned out one of the three blades was used to pull the airplane out of the tiedown spot. Use a towbar, instead. Run a hand down the leading edge while looking and feeling for stone nicks (v-shaped nicks can cause stress risers and failure of the blade tip).

While you're looking at the blades, start at the hub and look for grease—a sign of damaged seals. Periodically clean the blades so you can easily spot new leaks. Hartzell suggests a simple solution of dish soap and water to gently remove bugs, dirt and pollutants from the blade's surface. But use caution in spraying water directly into the hub, which can trash the seals.

No matter how well you care for a prop it will never be as pretty as it is the day it comes out of overhaul. It will develop nicks, which are sharp notch-like displacements of the blade's leading and trailing edge. What you have here is the start of cracks in the blade. And if you spot any cracks, they are grounds for immediate removal of the prop for a detailed inspection. While rare, you might also spot dents in the blade. Dents can cause local stress risers around their perimeter and under the surface. Leave your body filler in the toolbox—that's not an approved or effective repair.

The most common flaw on a blade is erosion. This is actually the loss of material from the blade's surface, and is more common on the leading edge close to the tip. The problem with excessive erosion is the setup for eventual corrosion. Keep the engine power as low as you can when taxiing on unfamiliar surfaces, and that also includes avoiding Beta in a turboprop.

Don't underestimate lightning strike damage, especially if you park outside. Evidence that a metal blade was zapped might include burned and melted areas or even a trail of small pits along the blade's surface.

A good source of propeller upkeep info comes from the FAA's AC 20-37E , which reinforces that only rated maintenance techs can perform any minor repairs (including filing, sanding, filling and painting) to a propeller. Keep the plane parked and lobby their help if you spot questionable damage.

—Larry Anglisano

Weights, washers and screws are used to achieve the correct balance.

BACK ON THE AIRPLANE

"As an experienced propeller overhaul shop we strongly suggest having the propeller dynamically balanced on the airplane—essentially marrying the overhauled prop with the aircraft's engine," Landis told me. He makes a good point that balancing problems cause vibration and a chain reaction of issues—everything from cracked spinners and cowlings, to premature wear of instruments and also pilot fatigue. Shops we talked with spoke highly of the RPX DynaVibe balancing system, which uses a handheld analyzer and accelerometer sensors that are attached to the engine to measure vibrational movement of the prop and the engine. Most shops also use a tachometer to measure the engine RPM during testing.

Once the system calculates the vibration magnitude, it suggests a solution for countering the imbalance with weights on the propeller's spinner or if it's a Lycoming engine, on the flywheel—both of which are equipped for mounting the weights.

Some propellers require frequent inspection, as is the case with some Hartzell HC-2Y-series props installed on some Lycoming 360-series engines. It's FAA AD 2006-18-15 that requires an electromagnetic Eddy current (ECT) inspection to check for internal failure of the hub, and the potential for the blade separating from the hub—which prompted the AD. I witnessed an Eddy current inspection performed on a Piper Arrow during my visit to the Sensenich shop. A single fine-winding ECT probe placed on the case of the hub creates a magnetic field within the metal and the instrument (via display) shows any discontinuities (a change in amplitude and phase) within the metal. There's little disassembly required other than removing the propeller spinner, and the inspection generally costs around $200.

According to the AD, the inspection must be accomplished every 100 operating hours, or at every annual inspection, whichever comes first.

REPAIR VERSUS OVERHAUL

As prop work is concerned there's either a full-up overhaul as we outlined in this article, or repair/reseal. During the reseal/repair of a constant-speed propeller it's disassembled, the components are

That's a newly overhauled and fully assembled four-blade propeller for a Beech King Air turboprop in the top photo. A recurring Eddy current inspection per the FAA AD is performed on a Hartzell prop hub on a Piper Arrow, middle, and a tech at Sensenich Propeller Services balances an overhauled prop off a Beech Bonanza, bottom.

cleaned, the old grease is removed, the old seals are removed and the tech will conduct a visual inspection. He or she is looking for corrosion and any obvious damage to the components. If all is good, the tech will dress the blade's leading edge while looking for nicks that can ultimately stress the blade. The blade may then be Alodined and painted. The propeller is then reassembled with new seals and balanced, and paperwork will be issued returning the prop to service.

To summarize an overhaul, the propeller is completely disassembled, parts are etched down to bare aluminum and an NDT inspection is performed. The steel parts are magnafluxed, dimensionally checked and any parts under limit will be red-tagged and replaced with a new or overhauled component.

Consider too that the manufacturer's overhaul manual requires replacement of seals, O-rings, bearings, retainers and other hardware. (That's generally not going to happen during the repair/reseal process.) The blades of course are reconditioned and repainted.

COST AND DOWNTIME

Pricing for propeller overhauls can vary widely by model, but our research showed that an overhaul on a basic fixed-pitch propeller might run anywhere from $1000 to $1500, while constant-speed propeller overhauls range from $3000 to north of $4000. Full-feathering turboprop overhauls can easily top $7000. These general prices don't include shipping, pickup and delivery, de-ice boots and other accessories. Re-pitching is generally an added expense. Depending on the workload of the shop and the complexity of the propeller, downtime could range from a couple of weeks to a month or more.

Worth mentioning is that propeller logbook entries are required to indicate the time since overhaul (or since new) and should be used as a general basis for subsequent overhauls, but periodic upkeep between the TBO period will likely be required. The engine to which the propeller is mated determines the pattern of vibration, stress and centrifugal force (10 to 25 tons) that props absorb and is related to the TBO. Calendar-time requirements are related to the life of seals and other components. Some props never reach the TBO because of corrosion, damage and because they're subjected to harsh operations (water flying and unimproved surfaces come to mind).

Inevitably, flying hours or calendar time will send a propeller to the shop for overhaul. If you fly a lot, how you care for it along the way can make the difference between making it to TBO or not. I think the best thing an owner can do is inspect it before every flight, keep it clean, keep the paint touched up and follow the prop manufacturer's maintenance schedule.

YouTube **See a prop shop floor tour video at http://tinyurl.com/j95ht2a.**

Which Oil Blend? Engine, Temp, Intervals

And those are only a few variables to plug into the decision-making formula. Start with the aircraft POH and any applicable engine service bulletins and ADs.

by Paul Millner

The article in the November 2019 *Aviation Consumer* on the new Phillips Victory aviation oil prompted lots of letters from readers asking how they might choose the perfect oil for their engines.

There isn't a one-blend, across-the-board pick, of course, but I can offer a straightforward guide for a logical decision-making process. Let's start with some nonsense, shall we?

TOO MUCH OF A GOOD THING? NOT

The horsepucky meter pegged when I got a note from reader Ross Oliver who asked me to backstop some odd advice he got from his service parts and engine oil supplier in Alaska. The harsh conditions in which Oliver operates his Cessna Skylane should be obvious, and after talking with his parts supplier he was in a quandary about which oil blend to use in his Continental engine.

"My local parts house recently told me that its AeroShell representative advised against using the CamGuard product with its AeroShell 15W-50 oil because it was too much of a good thing for my 182's engine," Oliver said.

To review, the CamGuard oil supplement product mates corrosion protection with additives for anti-scuff, deposit control and the conditioning of seals. This magazine has favorably evaluated the CamGuard product over the years, and field reports from users and shops have supported the conclusion. In my opinion, I think the Shell rep's remark sounds like marketeering, devoid most likely of technical content. We reached out to the company for further explanation multiple times, but it didn't respond.

Without explanation, I have to assume that Shell has not provided its reps with any technical background on CamGuard. And no, in my view CamGuard combined with AeroShell is in no way too much of a good thing. On the other hand, if you're buying CamGuard, you might question paying the premium for AeroShell multiviscosity, particularly since it contains TPP (once called TCP) which is not a good thing for your engine, since the Lycoming AD doesn't apply to this engine. The supposed benefits of TPP are provided by the CamGuard formulation. Consider using the less expensive but fully functional Phillips 20-50, or its straight-weight oil, if you prefer (same price). Here are some other questions and comments we fielded.

I want to use TCP/TPP to protect my engine against corrosion.

TPP doesn't provide that protection. When in the oil formulation, it provides an extreme pressure anti-scuff action when the camlobe bears down on the tappet body. But once the engine shuts down, there's no corrosion-impervious barrier provided by the TPP. If you fly less often than twice a week, and do not use an engine dehydrator, you are going to want some anticorrosion protection. AeroShell offers some protection in its formulation; *Aviation Consumer's* previous evaluations showed that CamGuard's protection is even more robust. Consider adding CamGuard. But, gather your

Reader Ross Oliver sent the top image of him operating his Skylane in Alaska. A CamGuard user, blending the additive with AeroShell's multiviscosity oil isn't too much of a good thing as his parts supplier suggested, but why choose an oil containing TPP? Maybe use the less expensive Phillips multiweight and add CamGuard. Open, inspect and replace the oil filter at every change.

own data. If you normally fly every week or two, then after two weeks of downtime avoid turning the prop, pull the top plugs and use your buddy's borescope to check for cylinder wall corrosion. Unfortunately, if you have chromed cylinders, this won't tell you much—the tappets could still be rusting. And even if you have a Continental, it's a bit invasive to pull a tappet for a look-see. If you have a Lycoming, nobody has quite yet figured out how to borescope or otherwise see a tappet face without pulling a cylinder.

I could relate to the mention in your article about the phosphate forming on the spring in the starter adapter on Continental engines, as I personally experienced this. I used to be a partner in an old Stinson with a Continental O470. After doing an oil change with AeroShell 15W-50, we started experiencing starter slippage. This engine had about 1200 hours and 25 years since overhaul at the time. Our mechanic blamed it on the semi-synthetic AeroShell, so I changed oil back to the Phillips non-synthetic and the slippage stopped.

It was most likely not the synthetic in the oil blend, but as you noted, the TPP (aka TCP).

I have only had the Cessna 182 for two years, but my flying seems to be about 80 hours per year, so I have been doing oil changes at about six months, which is always less than 50 hours between changes. You made an interesting point in your article about TPP being less stable than TCP, so Shell used a copper corrosion inhibitor to limit copper attack, but the phosphoric acid continues to attack seals and magneto cushions. I presume this issue is unresolved, suggesting that I should avoid AeroShell 15W-50 to avoid this problem (since I don't need the Lycoming anti-wear additive). If this were your engine, what would you put in the sump? AeroShell 15W-50 with no additional additive, Phillips X/C 20W-50 (without the Lycoming additive) with CamGuard or some other brand/combination?

I concur with not using AeroShell 15-50 in your engine. I use Phillips 20-50, plus CamGuard, in my own Lycoming.

Do I really have to change the oil filter at every oil change?

Well, you don't have to do anything except die and pay taxes. But it's wise to change the filter at every change, and cut it open to check for debris. Otherwise, you're leaving a quart of worn, dirty oil in the engine, reducing the effectiveness of your oil change by about 10 percent. And you're missing a great opportunity to perform due diligence on what's happening in the bottom end, in terms of evaluating oil filter debris.

When Lycoming announced it was reformulating the additive from TCP to TPP, I smelled a rat! I bought up all the old-style TCP additive I could find, and have been using that on my H2AD (aptly named) engine ever since. But, my supply is almost exhausted. What now?

Aren't you the enterprising guy! Have you done the engine modification to improve the tappet face? If your 172 is used for training and flying every day, utilization may well be high enough that the rationale behind the AD doesn't apply to your operation.

In any event, I can't in good conscience suggest you ignore the AD. You could apply for an AMOC (alternative means of compliance)

ENGINE LUBE 101: THE LOGIC PROCESS

The steps for choosing the right engine oil blend are based on simple and perhaps not so simple logic. Moreover, your value drivers may add some variation, but here I try to make my thinking apparent so you can evaluate what's appropriate for your engine and ops.

If you have a Lycoming O320-H2AD or O360E that requires Lycoming's anti-scuff additive by AD, then consider using an AeroShell oil with TPP (aka TCP); whether straight weight or multiweight depends on the temperature stability of your area or oil change interval. Alternatively, consider using Phillips straight-weight or multiweight oil, and add Lycoming's additive. The Phillips Victory oil solution will be less expensive, most likely, depending on how you source your oil—at the airport's FBO, from a local oil company jobber or from a mail-order high-volume retailer, as examples.

If you have a different Lycoming engine that the AD does not apply to, consider using Phillips straight-weight or multiweight oil depending on the temperature stability of your area or oil change interval, or AeroShell's non-augmented (no TCP/TPP) single-weight oils. Avoid the AeroShell multiweight and oils that contain TCP/TPP. If you fly less often than twice a week, consider using CamGuard ($23 per pint) to protect against corrosion.

If you fly a Continental engine with the starter adaptor, I would definitely avoid the augmented Shell oils with TCP/TPP (actually TPP now due to EPA toxicity concerns, but still called TCP in the trade due to tradition and history) and avoid the Phillips Victory oil. The TPP can adversely affect starter adapter spring operation. That leaves with you with either the straight-weight AeroShell, but not the AeroShell plus version, or the *non*-Victory Phillips blend, either straight-weight or multiviscosity oil.

Continental's thoughts on oil use are in both Service Bulletin MHS-24 and Maintenance Manual M-0, which used to be available on its website, but are now behind a third-party paywall.

The only downside to using a multiviscosity oil per se is that the VII, viscosity index improvers, do shear over time. These are the molecules that allow the multiweight oil to do the magic of being thicker at operating temperature than the base oil would otherwise be. If you're a 25- to 35-hour between oil changes pilot like me, that shouldn't be an issue. If you regularly run oil to 50 hours, and sometimes beyond, then multiviscosity may not be for you, or maybe you should consider exercising your quick drain more often. But your engine will talk to you—usually. If you never use a quart of oil in the first 10 to 20 hours, maybe allowing the oil level to drift down a quart or so from the 7 quarts or 10 quarts after a change (depending on your sump size), but then start using a quart every eight hours after that, the oil is talking to you. After that initial period, the VIIs are shearing, resulting in an effectively lower viscosity oil at operating temperature. And lower viscosity oil gets past the rings more readily, getting burned in the engine.

The viscosity index improvers (VIIs) are polymer chains, whose chemistry is made up of repetitive elements connected together. The conventional explanation (since 1958 at least) is that as the oil warms, the polymer coils unwind, making the oil more viscous than it otherwise would be at that higher temperature. More recent work suggests that is NOT true for all VIIs, but that other mechanisms are at work. What exactly the mechanism is in every case probably isn't important to the pilot; just know that the multiviscosity oil has these VII molecules to make it thicker at temperature than an unadditized mineral or synthetic oil. AeroShell's multivis oil is 50 percent synthetic; Phillips' multivis oil is 100 percent mineral oil; mineral oil is a better solvent for the lead salts produced by burning leaded aviation gasoline.

—Paul Millner

citing utilization, and proposing mitigations when/if utilization declines.

What is a VII molecule like and how does it work?

There are a number of different chemistries used, but the historical explanation was that the polymer uncoils as the oil warms, increasing viscosity compared to non-additized oils. There's additional alternative explanation of the mechanism now (see the scholarly paper at tinyurl.com/qumubj4), but the effect is the same.

As the oil warms, the VII acts to slow the thinning of the oil, providing better lubrication at operating temperature, while preserving good flow and pumpability properties at low-temperature starting conditions.

Contributor Paul Millner is a retired Chevron refinery engineer, a Cessna turbonormalized Cardinal owner and the technical editor of the Cardinal Flyers Online type club. Visit the club's website at www.cardinalflyers.com.

The Travel Air 4000 was a 1920s-era product of the prolific Wichita manufacturing company headed by Walter Beech, Clyde Cessna and Lloyd Stearman.

Buying The Old Ones: Homework Mandatory

Whether it's an antique, classic or one of the smaller warbirds, what you don't know will prove expensive. Education is ammunition.

by Rick Durden

Staggerwing.

Caught you.

It only took one word. You started dreaming. It's OK, we did too. In our mind's eye we saw that sleek work of art smoke over us at 200 MPH, 450-HP Pratt rumbling as it dwindled away toward the horizon.

Unless one's blood is the consistency of water, at some time every pilot has lusted after one of the grand antique airplanes seen at fly-ins, the classic hangared a few rows down or a nimble L-Bird—the warbirds that landed on roads to pick up generals and popped up over tree lines to spot enemy troops.

We'd been hearing questions about buying and owning the airplanes that have formed parts of our rich aviation history, so we started digging into what's involved in buying, caring for and flying old airplanes. We also took a look at a few examples.

WHAT'S OLD?

As we did our research we found that there was some disagreement as to how to label airplanes of differing ages. By and large, "antique" refers to airplane built prior to Aug. 31, 1945. After Aug. 31, 1945, there was no consensus as to what is a classic and what is "vintage." We threw up our hands and made the arbitrary decision to use a 60-year cutoff for this article. We looked at airplanes built in 1960 or earlier. From that date back to the end of World War II, we call them "classics." Prior to that, they're antiques. If they were pressed into service by the military in any role, they're warbirds.

Further, because we looked at the big warbirds (600-HP AT-6 and larger) in the August 2017 issue of *Aviation Consumer*, we limited our inquiries here to the smaller warbirds.

CALENDAR AGE

Our research made it clear to us that judging the airworthiness or safety of an airplane by its calendar age is a hopeless oversimplification. At the same time, calendar age is hugely important for many components of an airplane whether it be an antique, classic or just out of the showroom door. For example, hoses, in particular, become brittle with the passage of time and landing gear bungees lose their elasticity and will break under even moderate loads. We were warned of the risk of corrosion on Lycoming engine camshafts and Continental engine cylinders in airplanes that have flown only a few hours a year. Airplanes that are not flown regularly "age" faster and less gracefully, and are more subject to corrosion and associated ills of neglect.

We were interested to learn that because restoration projects can take years, those airplanes need to be treated as having "sat" for the duration of the project. We were told of airplanes just out of restoration having numerous components fail almost immediately because they were installed early in the project.

WHAT DO YOU WANT?

Warbird and antique owner and instructor Stan Musick started out our conversation by recommending that a prospective owner give a thoughtful answer to the question, "What do you want? Do you want to use it for transportation? Display it at fly-ins and airshows? Are you

The Boeing Model 75 is generally referred to as the Stearman, and is considered an excellent trainer for those who wish to step into antique-era biplanes, above. The Stinson 108, below, is a comfortable cruiser known for pleasant handling.

willing to be limited to flying on beautiful days?"

He went on, "What facilities do you have to house and maintain an airplane that may demand a great deal of care? Do you have access to a CFI who knows the type well for your initial and regular recurrent training? Can you get insurance? Can you afford to insure the airplane for a total loss?"

Finally, is the airplane of your dreams something that was built in limited quantities or has an oddball engine? Brent Taylor, president of the Antique Airplane Association (AAA) (www.antiqueairfield.com), told us that there were reasons that some airplanes were built in small numbers—they had lousy handling, questionable systems or less than great engines so pilots didn't like them when they were new.

EDUCATION

Texan Bob Steenbock, who has owned and operated antiques from Cubs through DC-3s, cautioned us that the old airplane and warbird world is purely buyer beware. "The FAA takes a hands-off attitude toward aircraft sellers and sales. It's a scary world out there. You'll run into people who don't have pure motives when selling and will pedal substandard airplanes and people who are selling junk and don't know it."

We were told again and again that a prospective buyer should do as much homework as possible and find a person who knows that kind of airplane and can serve as a guide to help find the right airplane.

Stan Musick was adamant, "Don't take advice from someone who is trying to sell you something. You're the tuna—the fish that feeds the other fish. What you don't know can cost you a fortune."

We were referred to the networking capability of the AAA by aviation author and decades-long Aeronca Champ owner Paul Berge. "Those folks either know the type of airplane you want or know who knows the type and can help you find an A&P and a CFI."

Brent Taylor echoed the cautions we had received and pointed us at two free FAA publications that had been created by FAA personnel working in conjunction with the AAA, EAA and AOPA.

He called for reading "Best Practices Guide for Maintaining Aging General Aviation Airplanes" (https://tinyurl.com/sojt3hm) and AC 23-27 "Parts and Materials Substitution for Vintage Aircraft" (https://tinyurl.com/usjr2pb).

We recommend going to Blakesburgh, Iowa, in September for the AAA fly-in—it is an ideal place to get to know old airplanes and the people who fly them.

Taylor enthusiastically agreed with others we had spoken with about the value of type clubs as resources for detailed information on antiques and classics. He endorsed recommendations that a checkout should be by a CFI who knows the type and can teach you how to do wheel and three-point landings in crosswinds—it's important to be able to do both. He also referenced the importance of being able to do a steep forward slip, as a number of the antiques don't have flaps and won't descend steeply even power off.

THE PAPERWORK

Antique aircraft owners told us that a careful inspection the airplane's paperwork prior to buying cannot be taken too lightly. The older the airplane, the greater the chance that there is some cloud on the title that can be expensive or even impossible to remove. If an owner can't convey clear title to the bird, walk away.

Order the full FAA file on the airplane at https://aircraft.faa.gov/e.gov/ND/ so that you get all of the 337s and STCs filed with the FAA. They may show major repairs not in the logbooks.

Go through the logbooks with a serious air of cynicism. Is the installed engine even legal for the airplane? It's surprising how often the installed engine or prop isn't on the FAA Type Certificate Data Sheet for that type airplane, making the airplane unairworthy until the correct one is installed.

Are all of the ADs complied with? How were they complied with? That's where an expert comes in. For example, the wood spar inspection for the smallest Aeroncas is a one-time event. Someone who knows those birds can tell you whether it was done correctly or the logbook pencil whipped.

How old is the fabric? Recovering even something as small as a Cub can run $30,000.

ENGINES

Parts availability for the engine should be a factor in selecting which vintage airplane goes in

TRAINING, CHECKOUT, INSURANCE

At first glance, flying an airplane built before 1970 isn't a big deal. The FAA doesn't get too excited about it in the regs. If the airplane of choice has a tailwheel, FAR Part 61.31(i) requires a tailwheel endorsement from a CFI if you don't already have one. Otherwise, the regs are silent.

There's no type rating required (we're talking about piston-engine airplanes weighing less than 12,500 pounds). You can legally hop into a World War I era Curtiss JN-4 Jenny and fly it.

Good luck.

If you've got a tailwheel endorsement, a huge pot of money and want to buy and explore flying an antique airplane, you can do so. If it's a breezy day, you might want to sell tickets as there's a good chance that you're going to provide some entertainment. It won't, however, be the sort that is enjoyed by people who treasure aviation's classics.

Bottom line, the older the airplane, the more likely it is to have systems and/or handling quirks/features that can get a modern pilot in trouble. In our opinion, a checkout from a CFI with experience in the type of airplane is essential.

Brent Taylor, president of the Antique Airplane Association (www.antiqueairfield.com), spent considerable time talking with us about the process of getting checked out in a vintage airplane. He repeatedly used the phrase, "Join up with the aircraft." He said that a pilot has to approach an antique in the context of the time in which it was designed and built.

For example, while aeronautical engineering was a burgeoning science in the 1920s, there was a lot that was not known about stability and control, plus, not all of the manufacturers knew about or were applying cutting-edge technology. Taylor told us that control harmony varied among manufacturers, with Travel Airs and Wacos having a reputation for being pitch-sensitive and having had heavy ailerons. He told us that the big biplanes of the late 1920s and early 1930s usually had big, powerful rudders while the monoplanes were more likely to be directionally unstable or neutrally stable.

We also learned that system design was all over the place in older airplanes —often meaning that such things as fuel systems are not intuitive to a modern pilot. Brakes seemed to be especially difficult for manufacturers to master—ranging from nearly worthless to a light touch will put you on your back (above).

Taylor strongly recommended that a person interested in buying an antique, classic or small warbird take advantage of the knowledge available in the various type clubs and at the Antique Aircraft Association, EAA and AOPA to find pilots, owners and instructors who have detailed knowledge of the particular type of airplane. Many of the type clubs have extensive background materials on the airplanes. That's especially valuable as there are virtually no Pilot Operating Handbooks (POHs) for airplanes built before 1970. Most have some form of Owner's Manual, but the amount—and accuracy—of the information provided varies massively. Type clubs can provide the missing information and point you to knowledgeable CFIs.

We can't emphasize a careful checkout too much. We've seen too many old airplanes bent by optimists.

We also were told by tailwheel antique owners that they helped themselves in the checkout process by starting out by getting comfortable in a Citabria (for monoplanes) or Stearman (for biplanes) before taking dual in the specific type they were buying, or bought.

For those seeking to own one of the L-Birds—small Pipers, Taylorcrafts, Aeroncas, Stinsons and Interstates—that went to war, we heard good news. Most were nearly off-the-shelf production airplanes with minor changes for military needs such as additional windows for spectacular visibility. Accordingly, a pilot current and comfortable in a Citabria should find little problem checking out in a Taylorcraft L-2.

With a "hardening" insurance market, we were concerned about the availability of insurance for antiques and classics. We found that there are dedicated insurance programs for the world of those who have an affection for old airplanes. One of the benefits of membership in the Antique Airplane Association is eligibility for insurance through the Butler-Brown Division of MidwestOne Insurance. We also found that type clubs and the warbird community have connections to insurance brokers and underwriters who have significant experience with specific types of older airplanes and often specialize in writing coverage for them.

The consistent word we got on insurance coverage for someone new to an old airplane was a requirement for a checkout from a CFI who knew the type—usually for a minimum of 10 hours of dual. In our opinion, that's completely reasonable.

Oscar Campbell's Taylorcraft L-2 began aeronautical life in service with the U.S. Army Air Force and still wears its wartime colors, top. Basic panel is nearly original, center. Joys of ferrying an airplane that has been sitting for years—lots of stuff breaks, bottom.

your hangar. Before rushing out to something that has a Kinner radial up front because you love the sound it makes, make sure that you have someone who can work on it and a source for parts.

In addition to a compression check and a look at the oil analysis history on a prebuy, we consider a borescope exam of the engine mandatory. With the low cost of oil analyses, if they haven't been done, take it as a caution flag that the owner wasn't serious about maintaining the airplane.

We also consider an airplane being sold with a "fresh overhaul" to be suspect. After all, if you're unloading the airplane, how much are you going to spend on an overhaul?

With that as background, we'll take a look at a few of the more popular of the old airplane crowd.

STINSON 108 SERIES

Anticipating the post-war aviation boom, Stinson created the Model 108 and equipped it with a 150-HP Franklin engine. Widely regarded for good handling and decent performance, more than 5000 were built.

We spent time with a pilot who had owned a 108 for over 30 years, but was unwilling to be identified. The first recommendation we heard was to join the owner's association (www.facebook.com/groups/20082572978/) and then find an A&P with experience with Franklin engines and Stinsons. That's important because Franklin engines need some specific tools. As a test, an A&P should be able to pull the forward spark plugs without taking off the nosebowl.

We were advised that anyone looking for a 108 should make sure that the Franklin engine has an oil filter—it's the best thing that can be done for the engine. Without an oil filter our owner told us that it's a 600-hour engine. With an oil filter it should last as long as a Continental or Lycoming.

A prebuy exam should include looking to see that the airframe is true and looking under the floorboards for repairs due to a groundloop. The base of the aft door frame is a corrosion point; check it carefully. Check the rudder rib at the base of the counterbalance for cracking.

As for brakes, Goodyears are bad, Bodell brakes are OK and Clevelands are good, but be careful—they are so good that you can put the airplane onto its nose.

TAYLORCRAFT L-2

In response to U.S. Army interest, Taylorcraft turned its Cub into an observation platform by creating what amounted to a bubble canopy—and it became the L-2 Grasshopper. For those considering a purchase, areas of concern are the same as its tube-and-fabric competitors: fabric age and condition, corrosion and quality of repairs after a groundloop.

We did get comments indicating that availability of parts for the small Continental engines are beginning to become an issue.

L-2 owner Oscar Campbell knew the L-2 he intended to buy. It had served in the Army Air Force within the U.S. and was sold as surplus following the war. It spent some time as a display in a museum, before being sold because the museum needed the money.

The L-2 changed hands a few times before the owner worked with his local EAA chapter, where it underwent a 15-year-long restoration. It then flew only sporadically before Campbell's careful prebuy exam and purchase.

Campbell and an A&P friend picked up the airplane in Northern California and began the ferry flight to its new home in North Idaho. It took three weeks. The first issue was a trim failure. Repairs were easy, but reflected the problem of an aircraft restoration by the committee system. The folks working on the L-2

The Cessna 195 is a sleek, roomy, five-place, radial-engine traveling machine, above. A photo of Cessna's plant shortly after WWII when multiple 120s and 140s were coming off the line every hour.

had forgotten to install cotter keys on the castellated nuts on the trim system and they vibrated off.

At the next stop, one of the ancient Eisemann magnetos failed. It had eleven hours total time. Campbell made the decision to install the kit converting the engine to Slick magnetos. Getting parts and making the change consumed a few days.

Taxiing out after fueling at the next stop, the left wing began to drop as the left main gear slowly collapsed. The problem? The calendar age of the rubber landing gear bungees. One had simply come to the end of its life and broke.

Campbell told us that he knew what he was getting into and was aware that he was going to have some problems because the airplane had not been flying. He went into it with his eyes open, patience and a healthy proportion of his budget set aside for repairs.

BOEING 75 STEARMAN

Four years after Lloyd Stearman sold his company to Boeing and took a job as president of Lockheed, what became the Model 75 Kaydet was hatched for the U.S. Army and Navy as a primary trainer—and forever after, everyone called it the Stearman. Over 8500 of the incredibly strong (10 G plus and minus) biplanes were built and, after being sold as surplus after the war, proved to be amenable to anything from crop-dusting to airshow work.

Because there are flights schools offering dual in Stearmans to this day, we consider it (or a new production Waco or Great Lakes) to be the stepping stone for anyone wishing to buy a biplane.

Because of the many mods available to the Stearman line, a careful check of the logbooks is vital. Was the airplane converted to be a cropduster and then back to a two-holer? How were the conversions done? Is the airframe true?

The airframe is tough, but not invulnerable. Look it over carefully. Putting the airplane onto a wingtip during an incipient groudloop is likely to break the rear spar.

Most of the stock airplanes had 220-HP Continentals or 225-HP Lycomings. There have been crankshaft issues, especially with radial engines that were built for tanks (the heavy things with treads and big guns) but later hung on Stearmans instead.

The stock airplanes barely have enough power to get out of their own way. 300- and 450-HP mods proved popular; however, no two seem to be the same. Expertise on a prebuy of a big-engine Stearman can prevent an expensive purchase mistake.

CESSNA 190/195

Cessna's five-place, tailwheel radial-powered singles had Continental or Jacobs engines ranging in power from 240 to 300 HP. More than 1000 were built (including the LC-126 military version).

The series has a high rate of loss of control accidents on landing. We believe that one reason is because of misalignment of the landing gear—something that takes some expertise to get right. Failure to properly maintain the tailwheel strut also leads to ground-handling issues.

We also consider the sight picture on landing to be a little unusual, causing new pilots to point the airplane at an angle to the runway when they think it's straight. This, tied in with gear alignment issues and the runway loss of control history require, in our opinion, an extensive checkout in the airplane by a CFI who knows 195s. A pilot should be equally comfortable with three-point and wheel landings.

Owners tell us that the original Goodyear brakes are satisfactory if they are carefully maintained. A popular mod is to replace them with the brakes from a Cessna 310.

CONCLUSION

Some of the most enjoyable flying we've done has been in antiques, classics and the smaller warbirds. We also recognize that they are from a time when systems were often counterintuitive, brakes were questionable and the stability and control meant challenges to a modern pilot.

We think ownership should be pursued with patience, a willingness to learn as much as possible about a desired airplane and setting aside at least a third of the purchase budget for things that will break.

TBM 940: Maximum Automation

Garmin's autothrottle opens the door to the next big step: Emergency autoland that will keep the TBM competitive with Piper and Cirrus.

AIRCRAFT FLIGHT TRIAL

BY PAUL BERTORELLI

Cirrus and Daher, builder of the TBM turboprop, have different aircraft design philosophies, but they share one thing in common: Both build and sell airplanes to a select, moneyed clientele who seem perfectly happy to trade in a relatively new airplane on the latest new model. Call it community-style marketing. The sales guys know their clients by first name and N-number.

The latest new model from Daher—the TBM 940—continues this incrementalist tradition with a new airplane that's outwardly little different from the previous model, the 930. Under the cowl, it's another matter.

Debuting last spring at Sun 'n Fun and Aero in Friedrichshafen, Germany, the 940 added an autothrottle to a class of airplane that's finally beginning to see such technology fully integrated into power management. Within a few months of that announcement, Piper and Garmin revealed their own version, but with a stunning distinction: emergency autoland capability. Cirrus has announced the same for the Vision Jet and although neither are yet certified for operation, they're expected to be shortly. Daher has no choice but to offer autolandl, too, and soon will, as an option on the 940. The company's Nicolas Chabbert said no formal announcement has been made yet, but customers are being told they can have it when it's ready and I'm sure buyers will check the yes box when asked.

For both Piper—who offers autoland in the new M600/SLS—and Daher, we're told autoland is a game changer in ginning up sales potential. That may or may not be true but the larger game to be changed is what this technology opens the door to: Eventual full-up, pilot-optional autonomy.

No one really knows how far off that is, but Garmin's autoland system clearly shows the airplane end of the equation is manageable. For the time being, TBM buyers can take a tween step with fully automated engine management.

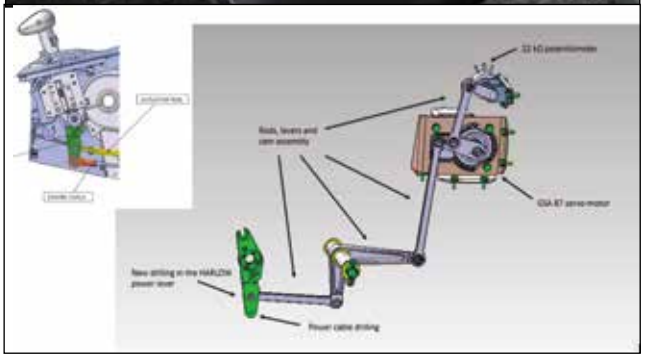
BIG AIRPLANE FEATURE

Autothrottles have been standard equipment on jet transports for decades, fully integrated into the flight management systems that are standard equipment on these aircraft. The technology trickled down to business jets and, lately, turboprop twins and singles too, with the introduction of the IS&S autothrottle system for the PC-12 and King Air models a couple of years ago. Mechanically, it's not especially complex or involved. Garmin designed a servo to operate the TBM's PT6A-66D's throttle through a mechanical interconnect. It is not, however, throttle by wire. There's still a hard mechanical connection between the cockpit power lever

The TBM 940 continues to advance technologically and remains a favorite for owners who want lots of speed and the ability to get into and out of short runways.

CHECKLIST

- Autothrottle is seamlessly integrated into the G3000 avionics.
- AT opens the door for the emergency autoland option. Daher will offer it when it's certified.
- Although AT improves operability, is the TBM line done with performance improvements?



Daher's Garmin-developed autothrottle can be engaged or disengaged by a button on the autopilot controller, top, or on the throttle grip itself, middle photo and red arrows. It works through a hard linkage and cam arrangement, lower photo.

there's also a new control unit called the GMC 711, an evolution of the GMC 710 which occupies the same real estate high on the panel just under the glareshield. The 710 had a speed button, but in the new version, that has been removed in favor of a function selector knob allowing either manual use of the autothrottle or FMS mode use. Garmin also shoehorned an additional button into the controller labeled AT. It toggles the autothrottle on or off and reiterates the button on the throttle lever.

and the engine throttle lever. Nor is it true FADEC, although the integration with Garmin's G3000—the complicated part—makes it almost function that way.

Garmin's GSA 87 servo is connected to the engine throttle lever through a cam arrangement that does two things: It physically (and visibly) moves the throttle during power changes and it allows the pilot to physically disconnect the system, either by overpowering it or with a button on the throttle lever and panel.

Along with that hardware change, the display also has some new CAS messages for out-of-limit engine parameters.

The AT version of the G3000 also gets some significant display changes intended to reduce pilot workload while at the same time integrating the pilot's attention to what the autothrottle system is doing. The display automatically shifts tabs around to suit the phase of engine operation. For example, on startup, ITT is critical, so that's emphasized.

On takeoff or other phases of flight, torque indication is more important so it's given prominence.

DIFFERENT THINKING

When I flew the TBM 940 out of Daher's headquarters at Pompano Beach, Florida, Nic Chabbert explained that pilots will need several hours of training to master the autothrottle and get the most benefit from it. Daher thinks this is better done in the airplane than in a simulator. Oddly, it's not so much that the pilot has to do much—he or she is actually doing *less*—it's just that without understanding the system, it can be confusing to see it do its own thing uncommanded.

It's also critical to grasp in addition to being a workload reducer for the pilot. Daher sees the autothrottle as an enhancement of the envelope protection the company has improved on in recent years. It has marketed this capability as the TBM E-Copilot and includes overbanking protection, stall mitigation—including a stick shaker—and emergency descent mode, a feature it developed after a high-profile accident that appeared to have been caused by a pilot incapacitated by hypoxia. The autothrottle's capabilities are now rolled into those always-resident autopilot subroutines.

TWO MODES

The autothrottle can be engaged in one of two modes, FMS or manual. In the FMS mode, throttle management is as close to full-up automation as pilots are likely to see in any aircraft at this stage of development. We used this mode when departing from Pompano's Runway 10. Chabbert explained that the FMS can be set up with a destination, waypoint and altitude in mind and all the pilot has to do is take off manually, switch on the AP and monitor.

On takeoff, advancing the throttle to 70 percent torque signals the AT to take over from there and it will automatically set the appropriate power for the rest of the roll and the initial climb. Once you're used to it, this has an obvious benefit. You can concentrate on looking outside and holding the centerline rather than worrying about niggling the power setting or over-torquing. If you're paying attention to business, you won't notice the throttle moving on its own, but it is.

For a pilot new to the TBM, the thing accelerates and climbs so quickly that it's easy to get behind it. Way behind. Even for an experienced TBM pilot, the AT helps because it frees up mental bandwidth for traffic scanning, radio work or other cockpit workload. It has some built-in smarts.

It knew, for example, that the airplane was still in Pompano's Class D airspace and when I pitched over to meet a 1500-foot altitude restriction, it automatically—and smartly—cranked the power back to hold the 200-knot indicated speed requirement. Once we cleared the Class D, it throttled back up to resume an optimum climb, even though we weren't headed to the flight levels. But had a route and higher altitude been plugged into the FMS, the AT would have handled all of the power setting at the appropriate moment.

"It's a system that's either zero or one. You choose to go manual or you choose to go through the FMS. We take off on FMS because the system knows where you are and what you want to do," Chabbert explained.

In manual mode, the AT can be set up for target speeds. It will simply take care of setting the power while the pilot worries about heading or altitude bugs, or flies manually. At any point, the autothrottle can be knocked offline by pushing the throttle-lever button or the engage button on the panel. But not *entirely* offline.

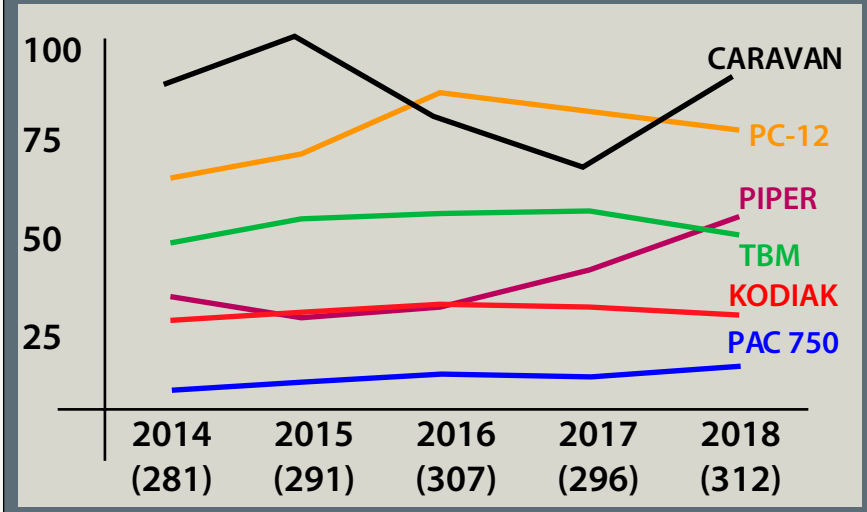
ENHANCED E-COPILOT

The AT system figures prominently in the TBM's envelope protection feature, the E-Copilot system. Daher's iteration of this capability includes an emergency descent mode, which automatically descends the aircraft from high cruise altitude and turns it 90 degrees off course if it detects cabin pressure loss and the pilot doesn't definitively respond to an aural and visual annunciation. The purpose of the turn is to alert ATC and potentially steer the airplane away from traffic on a busy airway or arrival.

The 940 features some new interior options, including heated seats and electronic device charging. Seating configuration can be set up for quick change.

Chabbert says giving the autopilot control of the throttle enhances the performance of emergency descent. "The autothrottle will always go to zero and then the autopilot to max Vmo of 260 knots. Once it reaches 15,000 feet, it will readjust

SE TURBOPROP: WHO'S SELLING WHAT?



In a single-engine turboprop market that doesn't lack for choice, the chart above shows that Piper has enjoyed the most vigorous growth. Piper's totals include two models, as do the Caravan numbers. During the five years charted, the overall market—less agplane turboprops—has expanded by about 11 percent, with Daher's share flat. With the purchase of Kodiak (see sidebar on next page), Daher's market share rises to the upper third and with aggressive marketing, may steal some sales from the Caravan.

to 50 percent," he says. This results in a faster, smoother descent to 14,500, which is deemed sufficiently low for a hypoxic pilot or occupants to recover and resume control of the airplane.

The AT figures in over- and underspeed protection, too. If the aircraft gets slow and nearing the stall regime, the AT adds power first, before activating the stick shaker and eventually pushing the nose down. In overspeed situations, it can reduce the power to flight idle while the pitch servo gets the nose pointed up.

I wasn't given enough time in the demonstrator airplane to gain any sense of how AT will affect approach and landing performance. Coupled approaches are nothing new and although I've never found data to support it, they certainly improve the technical quality of instrument approaches over those flown by hand. However, most pilots click off the autopilot at MDA or DA on an ILS and take it from there manually. That's where the trouble starts because the throttle and trim are reset, upsetting the stable speed.

However, the TBM's autothrottle can be set at the ideal speed—say 85 knots—then just flown to the threshold automatically at that speed. Chabbert told me he flies an AT-engaged approach right to the numbers and clicks off the system with the throttle button as he reduces power for the flare. Landing accidents in high-performance aircraft occupy either side of a divide between being too fast or too slow on approach.

The TBM doesn't have a well-defined accident pattern because it hasn't suffered many accidents. However, at least two have involved stalls or stall mushes on approach. Between the AT and the underspeed protection, the airplane ought to keep all but the most clueless pilot from wandering into that trap.

OTHER IMPROVEMENTS

Early 940s were shipped without the AT, but Daher developed a kit for field upgrades. Previous models can't be converted, however. In addition to the autothrottle system, new production 940s get an improved radar in the Garmin GWX 70, which includes turbulence detection and ground clutter suppression. There are also some new interior options. When autoland becomes available, it will be offered as an option on the 940, unless Daher changes its mind and adds something else to make it a new model.

Daher sees the 940 as both an incremental feature addition that adds utility and safety to the airplane and a transition to a new era. Once trained up on it, the autothrottle is definitely a workload reducer and limits worries about overspeeding or over-torquing. Whether that makes it a stronger seller against Piper's M-Class turbines or the Pilatus PC-12 is irrelevant. If those airplanes have autothrottle, Daher can't not have it if it expects to be competitive. Ditto autoland.

"I think it adds one more argument to the single-engine operation or for people who are looking at single engines being not as reliable," Chabbert told me. "Statistically, all the data is showing that the single engine is extremely reliable. But the autoland is going to add another layer of protection and comfort level. But I believe the autoland is mainly addressing companion concerns," he adds.

Chabbert says buyers almost universally spec fully equipped aircraft with invoices typically about $4.5 million. For more information on the TBM 940, see www.tbm.aero.

TBM GETS A BEARISH BROTHER

At first glance, the photo above might ignite a game of "which doesn't belong and why." But when it bought Quest Aircraft last year and renamed it Kodiak after the utility aircraft of the same name, Daher concluded just the opposite.

With growth hard to come by in a single-engine turboprop market that appears to be well served if not saturated, Daher saw Kodiak as an opportunity buy that could, at the stroke of a pen, not quite double its aircraft production.

"We believe this aircraft is going to open up some markets that the TBM can't tackle. We believe Kodiak is going to have more use for skydiving and it's a good platform for law enforcement applications," says Daher's Nicolas Chabbert.

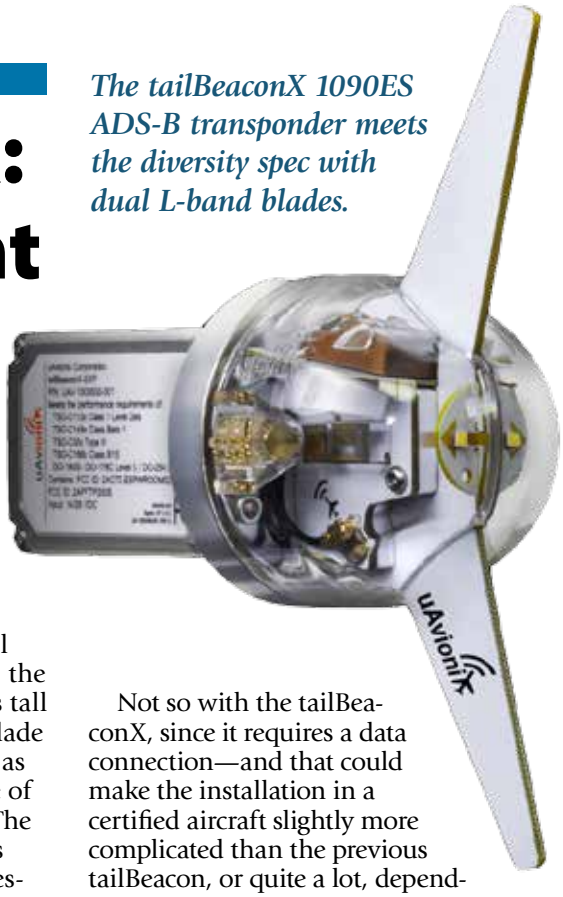
Those are market segments the TBM will likely never crack. Daher plans to keep Kodiak sited right where it is in Sandpoint, Idaho. It will spend the rest of the year gaining a better feel for the business before making decisions on potential integration.

"They have some metal working capability that is of interest to us. In Tarbes we are known for metal stretching and forming and that is of interest to Kodiak," Chabbert said.

uAvionix tailBeaconX: Transponder Tail Light

It might be easier to install than a panel transponder, plus it uses a control head that has backup instruments.

by Marc Cook



The tailBeaconX 1090ES ADS-B transponder meets the diversity spec with dual L-band blades.

Over the past year or so uAvionix made a name for itself with the innovative skyBeacon and tailBeacon ADS-B Out solutions. These 978 MHz UAT devices, intended to replace a wingtip strobe and tail light, respectively, proved popular for owners wanting a cost-effective way to get ADS-B compliance without having to invest in a new transponder or install other equipment inside the aircraft.

With the tailBeaconX, we can now see that these products were just a run-up in the company's product-development plans. Where the previous UAT devices would be fine for domestic U.S. compliance below 18,000 feet, they wouldn't work in Canada or into the flight levels; for that, you need a 1090 MHz Mode S transponder. And that's exactly what the tailBeaconX is. Moreover, uAvionix is working on Aireon compatibility—the GPS-based ADS-B equivalent Canada is considering.

We got our mitts on one of the first experimental versions of the product to try, as well as the company's AV-20 control head/flight instrument. uAvionix is working through the certification process for Part 23 applications. Here's a field report.

DIVERSITY SOLVED

The buzzword with Canada's space-based ADS-B proposal is diversity, which requires a dual-antenna transponder system and the tailBeaconX has it covered. The built-in antenna configuration is inherently "diverse," with top and bottom elements that will be needed for Aireon compatibility. Like the other "Beacon" devices, the tailBeaconX crams a lot into a small space. Weighing just 3.5 ounces, the tailBeaconX is a mere 4.4 inches tall (at the wings of the two small blade antennas), and 4.4 inches deep, as measured from the trailing edge of the antennas to the connector. The depth inside the tail-light well is only 2.3 inches. To say it's impressive to have a fully featured Mode S transponder and a WAAS GPS as well as antennas for both, and a bright LED tail light, in this one package probably understates the case. As impressive is the low power consumption: a flashlight-like half an amp.

It's fair to wonder that if the entire transponder is in the tail light, how do you control it? That's where the uAvionix (nee Aerovonics) AV-20-S and AV-30 come in. A two-wire RS-232 data connection is needed between the tailBeaconX and the control head, but that makes the system complete, allowing the pilot to control the transponder and provide it with baro information.

INSTALL NOTES

Obviously, the tailBeaconX is intended to replace a conventional tail light, like you'd find on thousands of Cessnas and Pipers. As with the previous tailBeacon, it's powered by the nav light circuit. And that was the brilliance, so to speak, of the skyBeacon and tailBeacon products: They were close to straight swap-outs for the lights they replaced.

As we've reported previously, we were able to install these devices in just a couple of hours, including doing the paperwork.

Not so with the tailBeaconX, since it requires a data connection—and that could make the installation in a certified aircraft slightly more complicated than the previous tailBeacon, or quite a lot, depending on maintenance access within the airframe. Almost certainly this will be easier than a full transponder swap, but it's not quite plug and play. Since it requires a set of wires to run from the tail to the instrument panel, it will be best to install the system while the aircraft is opened for other work.

As we went to press, the tailBeaconX was only available in the experimental version. That's where I came in, offering to test it in my GlaStar homebuilt. Just one problem with that. OK, two. First is that my aircraft doesn't have a tail light installed; it has the white rear-facing lights on the wingtips. And second

CHECKLIST

- The tailBeaconX is lightweight, draws low current and has excellent ADS-B Out performance.
- The control head is an added value with backup instruments.
- There's no ADS-B In and it isn't the slam-dunk-easy install of the skyBeacon or tailBeacon products.

In the tailBeaconX interface the uAvionix 2.25-inch AV-20 display serves double duty as a transponder control head and a multifunction flight instrument. We think buyers will prefer the larger AV-30.

is that the GlaStar design is a bit unusual in that it has significant overhang of the aluminum elevator above the short Fiberglas tail fairing. Think severe overbite without the need for orthodontia. Concerns of the tailBeaconX's antennas getting blanked by the elevator and the need to build a tail light mount into the existing (and painted!) tail fairing led to another option. I mounted the tailBeaconX inside the tail cone on a composite bracket, which puts it well away from pretty much all the metal in the airframe, save for the control cables running down the floor.

Any concerns that the location would cause performance problems were proved misguided after my test flights. The instrument itself shows NIC and NACp scores right on the face. NIC is Navigation Integrity Category, and ranges from 0 to 11. NACp is Navigation Accuracy Category for Position, and also ranges from 0 to 11. In order to be considered functional, ADS-B systems need to score 8 or above.

In testing, the tailBeaconX not only averaged above 9 in flight (and hit 8 sitting in the hangar) but the FAA PAPR reports showed no flags. Likewise, ATC had no issues with the transponder even at lower altitudes. The tailBeaconX might be small, but it had no problems getting the job done.

THE USER EXPERIENCE

Obviously, you're going to interface with this transponder in an unconventional way. For my flight testing, uAvionix provided an AV-20-S head unit, which fits into a 2.25-inch instrument hole. By itself, it includes multiple clocks, a backup attitude indicator, a calculated angle-of-attack indicator and the new transponder interface. The head unit's installation is as simple as providing ship's power, splicing into the pitot-static system and mounting it up.

Both the AV-20 and the larger AV-30 are meant to come in from the back of the panel, and feature common D-sub connectors (a DB-9 for the -20 and a DB-15 for the -30) so that part's easy. Incidentally, the tailBeaconX will interface with most common EFIS displays, so the control head is not a requirement for all installations. At least in the experimental class—for now.

The AV-20 powers up on the transponder page, which shows the squawk code prominently as well as NIC and NACp scores, mode annunciation and other menu items. To change the squawk code, you first have to press both lower buttons at the same time. (Touching one or the other scrolls through the available screens.) This step highlights the first squawk digit, which you can change through the left-side buttons. Then hit the right-side button to move to the next digit. When you're done, press both lower buttons to accept. To change modes, continue scrolling with the right button until the mode is highlighted, then change it with the lower-left button. When not in the set mode, the upper left button tells the transponder to ident or, with a long push, to reset the squawk to 1200.

Overall, the control scheme is logical but not nearly as easy as using a traditional transponder. None of the buttons are lighted, and finding and then pressing both in the heat of turbulence simply isn't as good as twirling four big knobs or jabbing a series of numbered buttons in sequence.

The AV-30 head unit, which also has a lot more functionality than the AV-20, portends an easier time of it; at least it has a rotary controller with a push-to-accept function.

THE BOTTOM LINE

Pricing for the tailBeaconX starts at $2199 for the experimental version, and $2999 for the certified version. Unless you have a compatible EFIS installed, you'll need the head unit, for $895 (AV-20-S) or either $1595 (AV-30 experimental) or $1995 (AV-30 certified). So for under $4000 in certified form, you get a new, very light, extremely functional Mode S transponder as well as bare-bones backup instrumentation. For homebuilts, the tailBeaconX represents a tantalizing combination of a strong primary instrument (in the AV-30) and a super-light Mode S transponder for under $4000.

For certified aircraft, the pending FAA-approved version of the tail-mounted device might be a compelling alternative to traditional panel and even remote-mounted transponders, especially with its diversity status. We'll keep tabs on the product as it progresses.

Contact www.uavionix.com.

ADS-B OUT PURGATORY

A year ago I opted for the wingtip-mounted uAvionix skyBeacon to meet the ADS-B Out mandate on my 1966 Cessna 182. The price was right and the installation, including paperwork, took only 2.5 hours.

Following the post-maintenance flight to make sure the system worked and qualified for the FAA $500 rebate, I ordered an FAA ADS-B Performance Report for the flight (it's free, at https://tinyurl.com/y9hrtsyw). Bad news. The unit had not met FAA specs. Bright red boxes, as at right, are the indication that your system failed to meet FAA standards.

That began a multi-flight exercise that was described in the June 2019 issue of *Aviation Consumer.*

Once I got a no failures performance report I was prepared for a long and happy life with ADS-B Out.

Foolish optimism.

On Oct. 28, 2019, I received an email from Scott Horejs of the FAA's Technical Aircraft Maintenance Branch in Des Plaines, Illinois, stating that my aircraft's ADS-B Out had failed to comply with the equipment performance requirements of FAR Part 91.227 on a recent flight. I was informed that in 45 days my aircraft would be subject to the filter described in FAA Notice FAA-2017-1194. That filter would prevent processing of ADS-B data transmitted by my aircraft. That would mean no ADS-B-based ATC and Traffic Information Services-Broadcast (TIS-B) services.

Yikes.

I contacted uAvionix. Trevor Mac of tech support got in touch with me almost immediately.

Over the next few days we worked out a game plan to figure out what was wrong. Once we got together, his test equipment indicated that the transponder's encoder was reporting that the airplane was flying at 1200 feet below sea level. I'd probably need a new encoder.

The next step was a call to Western Aviation on Felts Field in Spokane, Washington. I worked with the head of their avionics department, Tyson Davis. Of course, his shop was buried in work with the ADS-B deadline looming. Between his shop's and my schedules, as well as Pacific Northwest weather, I didn't get the airplane into Western Aviation until Dec. 16, 2019.

I kept Mr. Horejs at the FAA advised of the steps I was taking to get my ADS-B Out fixed.

U.S. Department of Transportation
Federal Aviation Administration
ADS-B Performance Monitor

Public ADS-B Performance Report

Other Checks

	Emitter Cat	Mode 3A
% Fail	0.00%	100.00%
Max dT	00:00:00	00:11:19
MCF	0	583

Following extensive troubleshooting, the problem turned out to be with the old King KT 76 transponder itself—it was toast. I opted to buy, and have installed, a used Garmin GTX 327 transponder that Western had on the shelf. I flew home, got on my computer and pulled up the performance report. Failure.

After cursing whomever first put an electrical system into an airplane so that there could be more components to break, I contacted Trevor Mack at uAvionix.

His reply was reassuring. "These errors are not associated with the transponder or encoder, it looks like that is fixed. These minor NIC errors are simply because we needed a little more stationary runup time prior to takeoff."

Bottom line, go fly in radar and ADS-B airspace for at least a half-hour.

On Dec. 29 the weather allowed me to climb above 10,000 feet over my home airport and remain for half an hour. I noticed that I received no traffic information during the flight and assumed that my ADS-B Out was being filtered. Good news—the performance flight showed no failures.

I immediately fired off an email to Mr. Horejs to inform him that all was well and attached a copy of the performance report.

Foolish optimism. I just don't learn.

Mr. Horejs responded to my email with the news that "because of the compliance history" with my airplane, additional flights with no failure indications were necessary before "this case can be closed." He followed up by saying that the FAA would like to see three or more successful flights.

Hmm, I was on double-secret probation and hadn't known it.

Yes, multiple confirmations make sense, but I don't have to like it. Trevor Mack told that such a requirement was pretty much standard.

Since then the weather and my work schedule have allowed one more flight. No failures.

As of this writing, I'm in ADS-B purgatory. Good part—Mr. Horejs confirmed that I can legally fly in ADS-B mandate airspace because the aircraft is ADS-B Out equipped and I'm trying to verify its operation. Bad news—my ADS-B Out is apparently filtered and I don't get ATC services based on ADS-B or TIS-B traffic information until its performance is verified.

This has been a frustrating, expensive pain in the whatsis. Nevertheless I have greatly appreciated the professionalism and willingness to answer the questions I've had as I navigate the mess on the part of Scott Horejs of the FAA, Trevor Mack of uAvionix and Tyson Davis of Western Aviation.

—Rick Durden

Cessna 177RG:

The retractable-gear Cardinal is a compelling used-market buy. It's stable, reasonably fast and an easy step-up single.

CHECKLIST

- The 177RG carries a decent load and delivers an honest 140 knots on 10 GPH.
- The airplane has crisp handling and makes for a stable IFR platform.
- Earlier models have less desirable hydraulic landing gear systems.

We've seen it plenty of times. A buyer on a budget has the heart set on a Cessna 210, but a closer look at market asking prices and operating costs squashes the idea. Luckily there's an alternative in the Cessna Cardinal RG. And overall there's a lot to like about life in a retrac Cardinal.

It has a strong, strutless wing and wide cabin doors that make getting in and out the 48-inch-wide cabin easy. As far as four-place retractables go, the airplane won't win any speed records, but it's easy to fly and makes for a stable IFR platform. Plus, what shop can't work on the familiar and reliable 200-HP Lycoming IO-360 engine?

As with most sought-after singles, a well-cared-for 177RG fetches good money—especially later-model airplanes with modern interior, nice paint and the latest avionics.

Among entry-level four-place retracs, it's faster than all but the Mooney, roomier than all but the Beech Sierra and has better useful load than any of the others. It's also hard to load out of CG.

HISTORY

The Cardinal RG is basically the same airframe as the fixed-gear Cardinal. This may not have been a favor to the RG, since the fixed-gear model, introduced in 1968, had a number of well-publicized problems that took a couple of years to sort out. The lack of power in the original FG Cardinal (150 HP) was fixed with an upgrade to 180 HP. Pulsing in the yoke during a full-flap slip was fixed with leading-edge slots in the control surface. The RG, however, started and stayed with a fuel-injected 200-HP Lycoming IO-360 engine and had the leading-edge slots in the stabilator from the get-go.

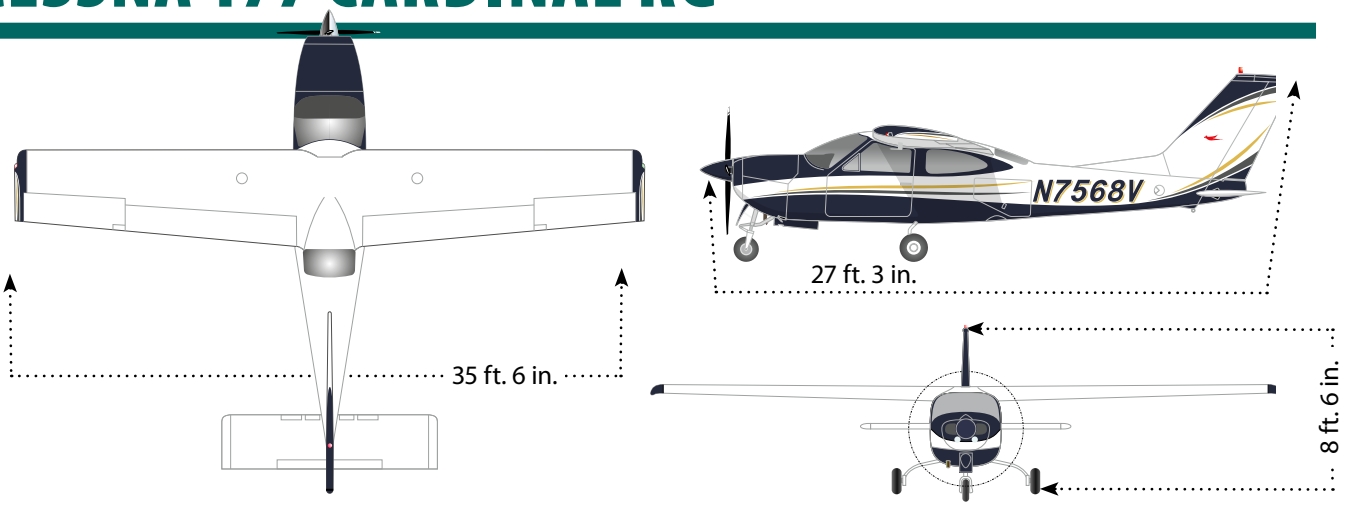
The Cardinal has a wider cabin than a Cessna 172 and 182, low sill height and wide doors.

The larger engine gives the Cardinal RG a welcome boost in gross weight compared to the fixed-gear airplane (2800 vs. 2500 pounds). Although empty weights are higher, the net gain in useful load is about 100 pounds.

The competition in 200-HP four-seat retractables at the time of the Cardinal RG's introduction in 1971 was fierce. Piper had been building its successful Arrow for four years, Mooney was well established with various flavors of the M20 and Beech had just started selling the Sierra. It was a lucrative market segment, attracting buyers wanting a high-performance single but without the means to afford a more powerful airplane like the Debonair. Cessna didn't help itself with a base price on the RG

The main landing gear on a 177RG folds back into the fuselage like the 210's. Owners like the airplane's stability and crisp handling.

CESSNA 177 CARDINAL RG

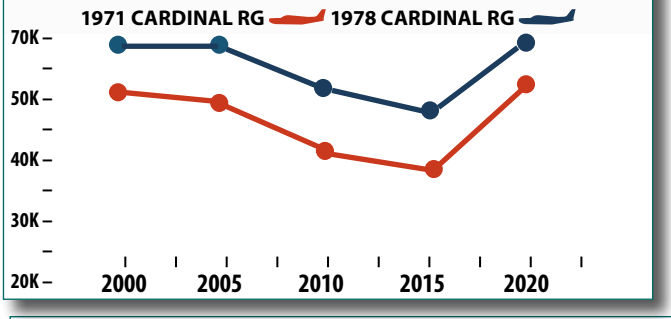


Drawings courtesy
www.schemedesigners.com

SELECT MODEL HISTORY

MODEL YEAR	ENGINE	TBO	OVERHAUL	FUEL	USEFUL LOAD	CRUISE	TYPICAL RETAIL
1971 177 CARDINAL RG	200-HP LYC. IO-360-A1B6	2000	$28,000	50	1170	135-140 KTS	$58,000
1972 177 CARDINAL RG	200-HP LYC. IO-360-A1B6	2000	$28,000	50	1155	135-140 KTS	$59,000
1973 177 CARDINAL RG	200-HP LYC. IO-360-A1B6D	2000	$28,000	60	1140	135-140 KTS	$61,000
1974 177 CARDINAL RG	200-HP LYC. IO-360-A1B6D	2000	$28,000	60	1140	135-140 KTS	$62,000
1975 177 CARDINAL RG	200-HP LYC. IO-360-A1B6D	2000	$28,000	60	1120	135-140 KTS	$63,000
1976 177 CARDINAL RG	200-HP LYC. IO-360-A1B6D	2000	$28,000	60	1093	135-140 KTS	$65,000
1977 177 CARDINAL RG	200-HP LYC. IO-360-A1B6D	2000	$28,000	60	1093	135-140 KTS	$67,000
1978 177 CARDINAL RG	200-HP LYC. IO-360-A1B6D	2000	$28,000	60	1093	135-140 KTS	$69,000

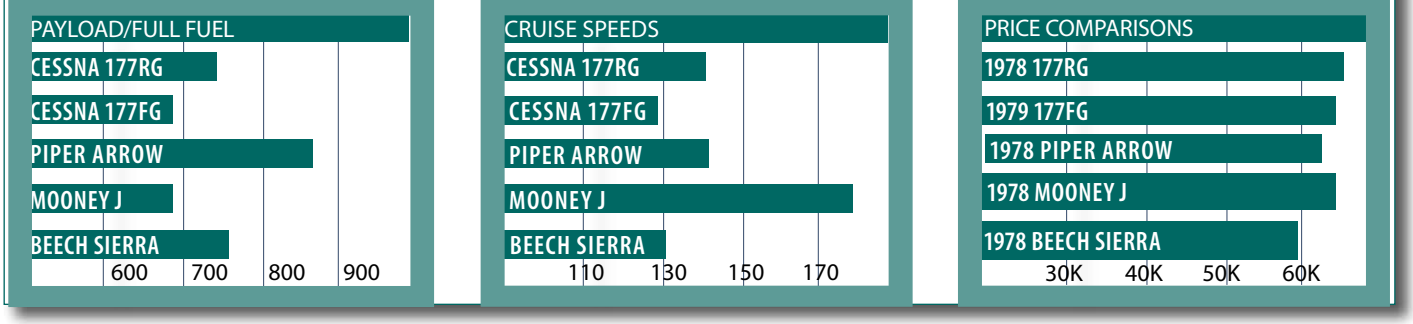
RESALE VALUES



SELECT RECENT ADs

AD 11-10-09	SEAT RAIL/ROLLER INSPECTION
AD 08-26-10	STATIC AIR SOURCE VALVE
AD 00-06-01	FUEL STRAINER ASSEMBLY
AD 97-01-13	FUEL, OIL, HYDRAULIC HOSES
AD 88-12-12	FUEL STRAINER QUICK DRAIN

SELECT MODEL COMPARISONS



Keith Peterson sent the top photo of his well-equipped Cardinal panel. That's an Aspen Evolution PFD, JPI engine display and a stack of Avidyne radios. That's an older (pre-1976) panel at the bottom sporting round gauges, Collins radios and early Gamin GPS.

of $24,795—several thousand more than the Mooneys of the time.

The original fuel system was an unusual (for Cessna) design that had only on and off settings. This occasionally caused problems, since it's possible for one tank to empty more quickly than the other. But ingenious Cardinal RG owners have found that this can be resolved in flight with a short but healthy sideslip. The tanks then feed equally for the remainder of the flight. The problem also occurs in later models with left-both-right-off fuel selectors, but here, the fix is simply to switch to the fuller tank for a few minutes.

There were several minor improvements to the Cardinal RG during its production run. The 1972 model gained a few knots in cruise and a slightly better climb rate thanks to a new prop. The gear system also gained some improvements, with mechanical switches moving to a more trouble-free magnetic setup. Both the hydraulic and electrical control systems changed, each step a small improvement. Also, the fixed cabin steps were dropped. They tended to expose the bottom of the fuselage to even more grief if the aircraft landed with the gear up. Instead, small foot pads were placed on the main gear struts.

In addition, landing and taxi lights were moved from the wing to the nose, a feature that many feel wasn't an improvement because the higher vibration levels in the cowl shorten the life of cowl-mounted landing lights

Prior to 1976, the instrument panel was higher in front of the pilot than the right-seat passenger. This was nice for the passenger but limited panel space for added avionics. In 1976, the instrument panel was redesigned and enlarged and a simplified landing gear hydraulic system was offered. This gear configuration was maintained through the end of production except for the powerpack change in 1978. For the 1977 model, the aircraft received a fuel selector that gave it commonality with other Cessna singles, had a more positive detent and was supposed to be more easily maintainable. And finally, in 1978, the aircraft got a 28-volt electrical system and an improved gear retraction power pack that cut retraction time in half, to six seconds.

Production of the Cardinal RG ended after the 1978 model year, with 1366 aircraft built. Unlike many designs, the 177RG didn't linger on with production trailing off to a trickle; about 100 airplanes were built that last year. However, in 1978, Cessna introduced the larger, more powerful Skylane RG and it's likely the manufacturer didn't want to wind up competing with itself. Interestingly, 177 Cardinals were also built in France under contract and these occasionally turn up in the U.S. These were internally corrosion proofed with zinc chromate.

SPACIOUS CABIN

Cessnas are big favorites with passengers, for several reasons. The cabins are generally quite roomy and the high wing makes for a cool, shady ride as well as a better view. The Cardinal adds to this with a wider cabin than the 172 or 182, low sill height and wide doors.

But those big doors—four feet wide—can be a problem on windy days. They're fairly light and can fly right out of your hand if they get caught by a gust, causing damage to the hinge or the skin ahead of the door, or both. The doors also have proved to be leak-prone. Some of the doors fit too tightly, others too loosely, due to either poor quality control in production, subsequent wind damage or both.

Air leaks mean cold air, and some Cardinal owners report that the back seat gets pretty chilly despite Cessna's attempts to warm things up with heater ducts. Careful sealing of potential air leaks in the cabin can bring some improvement, but a lap blanket for back-seat passengers is useful when the ambient temperature falls below zero.

Many owners assume that if the door leaks air, it also leaks water. The windshield has also been implicated in water leaks. But water leaks, for the most part, seem to come from the fairing joint at the wing root and owners and mechanics have come up with a fix for this leak that owners can do easily. Still, many owners find a hand towel is a useful checklist item for IFR flight.

As noted earlier, visibility from the front seats is among the best in any Cessna. With the seats forward in flight position, the pilot sits about even with the wing's leading edge. This allows a view around the wing during maneuvering. The seats themselves could be ordered with vertical height adjusters—a boon to both short and tall pilots.

At the other end of the cabin, the baggage compartment is, to put it mildly, oddly shaped. Cessna had to put the wheels somewhere and they wound up in the baggage bay. The usual Cessna cavern has a big hump in the middle of it, right next to the baggage door. This sounds worse than it is in practice. The baggage compartment holds a huge volume and Cardinal RG owners use the hump as a divider. The baggage door is wide, but what won't fit through the baggage door will go in over the back seats.

One owner commented: "We had occasion to stuff the entire contents of a freshman girl's dorm room into the baggage compartment one time. Well OK, her trunk had to go into the back seat, but everything else went into the baggage compartment. Try that in your Mooney."

An interesting exercise is to try to load a Cardinal RG out of CG. It's tough to do. You are more likely to go out the front end of the envelope than the back, especially with a heavy pilot and instructor and no baggage. In the Cardinal RG, at least, the 25 to 50 pounds of undefined "stuff" most of us leave in the baggage compartment becomes useful to counteract forward-CG problems.

Part of the appeal of owning a strutless Cardinal is the ease of ingressing the cabin through the wide doors, but hang on to them on windy days. Top photo courtesy of Mike Guidry. Once inside, the cabin is wide (48 inches), and the rear seat is reasonably accommodating for full-sized adults.

DECENT PERFORMANCE

Pilots say that the Cardinal RG makes for a good, stable instrument platform, but it's still nimble. "Compared to a Skylane RG," said one, "it's like a sports car." As noted above, the speed is good in its class, although not up to that of the Mooney. Owners report cruise of about 140 to 145 knots at 11 to 12 GPH, or about 135 knots at 9 to 10 GPH. The RG doesn't get its speed from raw power, so proper rigging is important in obtaining book speeds.

Cessna's flaps are among the biggest in the business and the Cardinal RG uses them to get respectable short-field performance for a four-place retractable. Landing distance over a 50-foot obstacle is a claimed 1220 feet, shortest in its class.

Despite the higher horsepower, the Cardinal RG's takeoff performance (takeoff roll: 890 feet, and 1585 feet over an obstacle) falls short of the later fixed-gear Cardinals (750 feet and 1400 feet over the obstacle). While some of this is due to the higher gross weight, another factor

That's an uncowled turbonormalized 177RG pictured at the top, and its TA0411 turbo, bottom, which is responsible for 800 FPM climbs to 17,500 feet. Trimmed out and pulled back to 80 percent power, it'll do 177 knots on 10.8 GPH.

is the large nosegear door that sits immediately behind the propeller when the gear is down. Cardinal RG pilots say they can tell if the nosegear is down without looking at the gear lights simply by the vibration the gear door induces. This vibration also means that the nosegear door hinge is an item to watch for wear.

Because all three gear legs retract aft, there is a noticeable pitch-trim change during both extension and retraction. On takeoff, experienced owners take advantage of this by letting the aircraft accelerate to the target climb speed and then retracting the gear. The change in CG brings the aircraft into climb attitude with almost no pilot input.

The pitch change during gear extension is easily canceled by lowering 10 degrees of flaps at the same time. In IMC, some pilots like to take advantage of the gear's drag and pitch change by lowering it right at the outer marker. If you set up your speed carefully in advance, you will find that only slight power adjustments are necessary to maintain a stabilized descent on a 3-degree glideslope.

The stabilator in the Cardinal RG has been the subject of a lot of discussion. While it's less sensitive than some other stabilator-equipped aircraft, it's much more sensitive than the stabilizer/elevator combination that most Cessna pilots know and love. More than a few folks transitioning from the 172 or 182 to the Cardinal RG have embarrassed themselves by crow-hopping down the runway. A good checkout with careful attention to the special needs of the stabilator is a must, but once mastered it becomes a non-issue.

LANDING GEAR TWEAKS

Through the eight years of its production, the Cardinal had four different landing gear systems, as Cessna strived to correct all its quirks. Major components remained the same but plumbing and controls evolved. The first, most problem-plagued one on the 1971 and 1972 Cardinal RGs was a Rube Goldberg combination of electrical and hydraulic components. Its weakest links were electrically actuated main gear downlocks and mechanical position switches.

The 1973 Cardinals got magnetic position sensing switches, which held up better to the elements, hydraulic downlock actuators that improved reliability and direct control of the gear movement through a hydraulic valve rather than an electric switch. By 1974, the hydraulic system was almost completely in control of the gear, although a complex electrical control system remained. There are many stories told about Cardinal gear issues, most of them inaccurate, but perhaps more than any other Cessna, the early Cardinal gear systems benefit from a mechanic with prior Cardinal knowledge.

In 1976, Cessna finally got it right, removing all of the electrics from the gear system in favor of fully hydraulic gear using only two switches: a pressure switch to control the hydroelectric gear pump and a squat switch to keep the gear down while on the ground. While any of these gear systems are dependable if properly maintained, 1976 and later Cardinal owners are most likely to report a fully trouble-free ownership experience.

Finally, with the 1978 models, the 12-volt Prestolite hydraulic power packs were eliminated in favor of a 24-volt power pack of Cessna's design. This has proved to be the most satisfactory of all the gear systems and, of course, would be the one to choose if cost considerations and availability permit—only 100 RGs were built in 1978.

There are other landing gear issues too, not related to the hydraulics. The most serious is the main gear actuating cylinder rod ends, which had a nasty habit of breaking off at inopportune moments, rendering the main gear inoperative. Actually, the main gear dropped to in-trail position and for a while, there was talk about carrying boathooks to reach down and pull it into the locks. But replacing the rod ends is a more permanent solution. Have your mechan-

Sherif Sirageldin's 1975 177RG sports some sharp paint work. It has extended-range fuel tanks and enough speed mods to see 150 knots true.

ic check for grease zerk fittings on the rod ends. If they are there, you have the old rod ends.

At any rate, buyers should check to see which, if any, of Cessna's recommended service instructions have been applied to the model being considered. There are at least eight of them that come to mind, including numbers 71-41, 72-26, 73-28, 74-26, 75-25, 76-4, 76-7 and 77-20.

The landing gear raises the issue of proper maintenance. Experienced Cardinal RG owners will tell you that properly maintained, the landing gear is every bit as reliable as the gear on any other aircraft. The problem is finding a mechanic who really understands the landing gear, as well as the rest of the airplane. Proper rigging of the gear is set forth in great detail in the maintenance manual and careful adherence to these procedures usually results in a reliable landing gear system. This is where the owner organization proves its worth, with a lot of useful and detailed advice as well as referrals to knowledgeable Cardinal mechanics.

MAINTENANCE ISSUES

The Lycoming IO-360-A1B6D engine in the 1973 to 1978 Cardinal RGs has a couple of notable idiosyncrasies. One is that it uses the infamous Bendix dual magneto that puts two magnetos on a single shaft, making the shaft a potential single-point failure item that can rob you of all engine power instantly if it fails.

The Cardinal RG is not the only aircraft using a dual-magneto engine—some Mooney models and Beech Duchess models do also. The 1971 Cardinal RG used the IO-360-A1B6 engine, with separate magnetos. This engine is approved for all Cardinal RGs, but getting an exchange at overhaul time can be costly. The dual-magneto engines were recently a subject of Special Airworthiness Information Bulletin NE-06-08, which alerted owners and mechanics to a prop governor hazard that "could result in loss of engine oil leading to engine failure."

Not only could it, it has. The oil loss results from omission of a plate between the prop governor drive pad and the prop governor itself. The plate is between two gaskets and is often thrown away with the gaskets when the old governor is removed. Unfortunately, the gasket without the plate often takes 15 minutes or so to fail, setting up the pilot for an off-airport landing.

SUPPORT ORGANIZATION

We think one of top selling points for all Cardinals is Cardinal Flyers Online (CFO). This model-specific organization with over 2000 members maintains a large and complete website (www.cardinalflyers.com) that is a treasure trove of data and advice on Cardinals. Much has been contributed by members, but the operators of the site, Keith Peterson and Paul Millner, have become experts in every detail of Cardinals. CFO was the first organization to call attention to the prop governor

CARDINAL RG CRUNCHES: ENG/MECH

The things that struck us as we reviewed the 100 most recent Cardinal RG accidents were what we didn't see—there were almost no bounced landing events (one) and for all the hand-wringing over the reliability of the landing gear on single-engine Cessna retracs, only three resulted from a mechanical problem that prevented gear extension.

The fixed-gear Cardinal series has a history of bounced/porpoised landings leading to firewall damage. That simply isn't the case with the RG model. Our working hypothesis is the different landing gear geometry. No matter what it is, we were impressed by the absence of touchdown problems with the RG. We can't recall another aircraft we've reviewed with such low numbers. Also, we only saw two landing overshoots—and one was a student pilot on a 1500-foot strip—an unusually low number.

The good news regarding landings in the 177RG continued in a low rate of runway loss of control (RLOC) accidents, only 8 percent. We've always liked the Cardinal RG's crosswind capability—the low RLOC number seems consistent with that opinion.

While six inadvertent gear-up slides to a stop is about average for retractable-gear airplanes, we have to go back to the near absence of landing gear mechanical issues. That's a solid indication of good system reliability rather than especially good maintenance. We think that's true because we saw strong evidence that Cardinal RGs, overall, haven't been subject to outstanding maintenance. It shows in the rate of engine/mechanical-related accidents.

Engine stoppages led to 28 forced landings with airframe damage. Of those, the majority were because of maintenance that was performed improperly. Maintenance guru Mike Busch has written about the risks of cylinder replacement. He might have been referring to the Cardinal RG. Ten catastrophic engine failures were caused by improper cylinder installation—usually failure to correctly torque bolts.

The single-drive magneto on the RG's Lycoming engine has come in for criticism. We saw three magneto failures, but only one was of the drive.

At 13, the fuel-related accident rate seemed high. There were no reports of pilots running a tank dry and not getting a restart. (Early RGs had an off/on fuel system; later ones had left/right/both selections.) All but two of the accidents involved pilots running out of gas—we can't help but wonder if poor fuel quantity indicators played a role. There were two water contamination accidents.

One pilot reported that he had to keep "increasing the mixture" on a hot day to keep engine temps down. He increased the mixture until he ran out of fuel.

Of the eight VFR LOC/stall accidents, most were on takeoff and often at high altitude and/or over gross weight.

The drag of the gear is low, so there's no hurry to retract it. Two pilots discovered that reality. One had the engine quit soon after liftoff. He didn't have time to put the gear back down before landing on the remaining runway. The other caught some wind shear after gear retraction and hit the left tip of the stabilator on the runway.

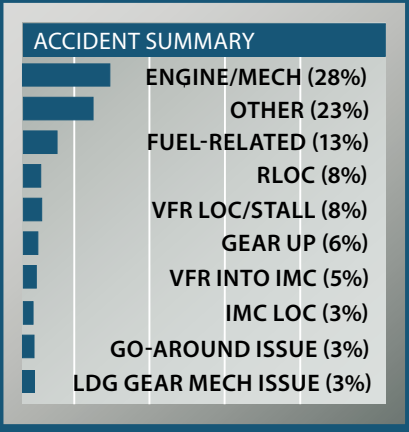


plate problem and was instrumental in getting the recent SAIB published. Most of the fixes or techniques noted in this article have been documented on the CFO website.

In addition to the website, CFO sends out an almost daily email digest containing messages from members, replies from other members and comments from both Millner and Peterson. Past digests are maintained on the site, with a search facility that lets you search all the digests from the most recent (#5122 at this writing) to the earliest digest in March 1997. Membership in CFO is $34 a year.

MODS

You can turn the airplane into a fast flight level flyer with a turbonormalizing system from Tornado Alley Turbo at www.taturbo.com. When we reviewed the mod in a flight trial way back in the May 2009 *Aviation Consumer* we saw 177 knots (cool coincidence) at 17,500 feet. North of $40,000, the mod won't be worth it to many for a four-place single in this price segment, but it will for some and we think they won't be disappointed.

Speed modifications of various kinds are available from several sources, including wingtip mods and fairings for the exhaust pipe, and Maple Leaf Aviation is a popular go-to. Contact them through www.aircraftspeedmods.ca. Vortex generators are available for the Cardinal from Micro Aerodynamics at www.microaero.com.

Hartzell and McCauley continue to offer three-blade prop conversions. Contact www.hartztellprop.com and McCauley at www.mccauley.txtav.com.

CURRENT MARKET

According to *Aircraft Bluebook*, retail prices for the 177RG have been on an upward trend. While the latest models of the 177RG (1978) have a typical retail value of around $69,000 (per *Aircraft Bluebook*) we found asking prices to be higher for models with new paint and fresh avionics upgrades.

We found one offered by Van Bortel Aircraft in Texas for a whopping $109,500. It had 1151 hours on the engine since overhaul, but older avionics and decent paint. Another

1977 model was listed on an FBO bulletin board for $90,000. It had new Garmin avionics, including a primary flight display and custom panel, new paint, newer interior and 500 hours on the engine since factory new. Use the pricing in the data sheet on page 25 as a starting point, but expect to pay more.

OWNER COMMENTS

I own a 1975 177RG and have been very happy with it. I purchased it in 2001 and it took several years to get it to where I want it, doing gradual updates and new paint in 2015.

The panel is a bit outdated with a Garmin-AT GNS 480 GPS navigator, MX20 multifunction display, SL30 navcomm radio, a King HSI system and an all-electric Kelly Manufactuing RCA2610 digital attitude indicator with battery backup. A Garmin GTX 345 transponder meets the Mode-S, ATCRBS and ADS-B Out requirements. There are better panels out there, for sure, but this one does provide for a very capable IFR platform.

The Cardinal RG is a comfortable plane with plenty of room for four people. The large doors allow easy access for passengers. On the downside, the landing gear hump makes loading the baggage compartment a bit annoying with larger-sized carry-on bags.

Currently configured with all seats in, it has a useful load of a bit over 1000 pounds and the airplane has a 60-gallon fuel capacity. So legal max gross weight is easy to hit with full fuel and American-sized passengers. I do have an extended-range fuel tank (60 gallons) via an STC that includes a letter from Cessna for adding another 700 pounds to its max gross weight. But I've only used that for one flight.

The airplane handles most runway surfaces very well. I have landed on sand in Copalis, Washington, grass in Center Island, Washington, and delivered supplies to an island rocky runway in La Gonave, Haiti, for the 2010 earthquake recovery efforts.

One downside is the small wheels. I have skipped landing on some grass/dirt fields because I wasn't sure I could handle what I thought were some surface irregularities (difficult to tell from the air), and it would be a bit too late when landing to find out my wheels weren't large enough. It would be nicer to have C210-size wheels, but I guess one can't have everything; plus the baggage compartment would be inaccessible with any larger wheels.

The retrac Cardinal is a clean airframe with a decent cruise speed as proof. Owners report typical speeds in the 140-knot range, and a bit faster with speed mods.

I have flown it across the country many times both alone and with passengers. The passengers have all commented positively on its comfort. I have also used it for delivering hurricane supplies in the U.S. With the rear seats out it has a large storage capacity, and for the Haiti mission I also removed the copilot seat for even more storage space. With some aftermarket fairings (from Maple Leaf Aviation), I consistently cruise at 150 knots true between 5000 and 8000 feet on 10.5 GPH with a light to medium load, including me, a passenger and fuel tanks at three-quarters full.

Running lean of peak, I burn between 8 and 9 GPH and cruise at 140 KTAS. With the extended fuel range, its endurance now outlasts my bladder (I've gotten older and it has, apparently, shrunk with age along with the rest of me).

Sherif Sirageldin
via email

When I owned my Cessna T210 Centurion my flying mission was much different than today. With its great range, awesome payload and predictable Cessna handling, this wonderful high-flyer took myself and my family, the dog—and just about whatever we could fit—anywhere we needed to go in air-conditioned, above-the-weather comfort. That was then.

With flying about recreation these days, I said goodbye to the Centurion but kept I kept the skills up by flying the venerable Cessna 182. But for my next airplane I wanted economy and some degree of speed performance. Two cabin doors and retractable landing gear was a must. Enter my new Cardinal RG with its roomy cabin, decent speed and impressive economy thanks to its fuel-sipping, fuel-injected 200-HP Lycoming IO-360.

Easy to fly, easy to get in and out of and with pleasant flying manners it's been an easy transition from my beloved T210. Memorize a few V-speeds and it's an absolute pleasure to fly. With a few checkout hours with a very knowledgeable CFI, I had no trouble ferrying this machine from Wisconsin to my home field in Connecticut.

With six weeks of flying the 177RG under my belt, it's been a great transition so far and I look forward to many years of use. With my high-performance retrac time, insurance is around $1800 per year.

My Cardinal cruises at around 130 to 140 true on 8.5 GPH. It's a high flyer, but I fly the East Coast. There's a great community with Cardinal Flyers Online owner's group.

Mark Hagopian
via email

The Aviation Consumer

Used Cardinal RG

(continued from page 31)

We purchased our Cardinal in 1987 after two years of Cessna 152 ownership. It was the perfect step-up family aircraft for us, offering excellent cross-country speed and range in true comfort. The four-cylinder engine brings an economy of operation and maintenance, and systems like rudder trim and bullet air vents provide the capabilities of fancier airplanes.

It has provided decades of safe and comfortable travel for our family of four, making countless trips to grandparents and around the country. With upgrades like paint, interior and a glass panel across the years, our Cardinal remains an outstanding balance of ability and affordability. We greatly enjoy being in the community with other Cardinal owners through the Cardinal Flyers.

Cardinal Flyers Online was founded in 1997 with the purpose of bringing Cardinal owners together for safety, savings and fun. We have enjoyed over 20 years of providing technical knowledge, sharing experience and providing social interaction, events and gatherings. Cardinals are usually personal aircraft and seem to be more pampered and upgraded than other models. Cardinal Flyers members possess a remarkable depth of knowledge and a willingness to share that knowledge while welcoming new owners. We have been proud to provide the organization within which so many owners have made good friends and receive enduring value.

Cardinal Inspections (www.cardinalinspections.com) leverages over 30 years of experience with an exclusive focus on Cardinals to provide services to buyers, sellers and owners. Services include in-depth Cardinal inspections at any location, buyer assistance with shopping, evaluating and transacting, and seller assistance with listing, pricing and negotiating. Cardinal Inspections helped over 70 clients in 2019 and aspires to be the best path to Cardinal ownership.

Keith and Debbie Peterson
via email

This panel in this fixed-gear Cardinal is worth showing. It has a Dynon SkyView Certified avionics suite with a 10-inch display, and Dynon autopilot and backup EFIS. Clean, indeed.

LAKE AMPHIB

It's time to take a fresh look at the used Lake amphib market for the *Aviation Consumer* Used Aircraft Guide. We want to know what it's like to own these seaplanes, how much they cost to operate, maintain and insure and what they're like to fly. If you'd like your Lake to appear in the magazine, send us any photographs (full-size, **high-resolution**) you'd like to share to the email below. We welcome information on mods, support organizations or any other comments. Send correspondence on the Conquest by May 10, 2020, to:

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