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The Aviation Consumer

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FIRST WORD

ADS-B DEMAND: LIKE RUSH HOUR AT STARBUCKS

That's a good analogy for the looming last-minute ADS-B equipage rush, less the satisfaction of a fresh espresso. Ric Peri, my go-to at the Aircraft Electronics Association for anything related to the ADS-B equipage mandate, reminded me that the last-minute long lines will be because buyers haven't been motivated to spend money on gear that might not add functionality to the aircraft. Expecting otherwise is unrealistic. Peri's finger has been on the ADS-B mandate pulse since day one and without exact numbers, he estimates that roughly half of the fleet is mandate compliant. If I read his body language, Peri doesn't see a real solution for the growing install backlog as a result, even handing over some installations to A&P mechanics.

While the concept is nothing new, that's what uAvionix is doing with its Qualified Installer Mobile Installation Network, inviting repair shops and mechanics with IA (Inspection Authorization) credentials to sign up for prioritized support, product training and discount pricing on the product. It's similar to what Dynon is doing by adding an IA to the STC for its Certified-series Skyview integrated avionics. On the surface, it's a logical approach to spreading the install demand. Like most major mods, ADS-B installations can be signed off by either A&P mechanics who hold a valid IA or certificated Part 145 FAA Repair Stations, which most avionics shops are.

As we've been reporting, not all, but many, of the uAvionix Beacon-series ADS-B installs can be accomplished in around one hour, although strobe installs will take longer. At a $110 per-hour labor rate, that's easy math to swallow, although shops are flat-rating some installs, based on the wiring and wingtip design. For basic interfaces, the retrofit might be one of the easiest tasks on an IA's to-do list. It might take longer to prepare the return-to-service paperwork.

uAvionix company President Christian Ramsey called it straight, saying uAvionix "recognizes the potential for supplemental capacity and income." Simple—it sells more units, A&Ps get more work. The skyBeacon, which recently earned an FAA TSO, is priced at $1849 and is shipping from a backlogged inventory. In addition to rule-compliant ADS-B Out, the product has an LED strobe and LED navigation light. The ad propaganda says mounting the device is done in under 10 minutes, for wingtips that accommodate a drop-in-place install. After eyeballing the install data, it really is simple stuff.

For others, like a wide variety of single-engine Cessnas, uAvionix sells optional wingtip adapters. For a Skylane, it's priced at $100. Thinking ahead, uAvionix included the optional fairing in the skyBeacon's STC manual to avoid additional approvals. uAvionix said it will publish a directory of associated installers on its webpage.

Someone recently asked if I thought the concept of manufacturers opening up avionics installations to A&P mechanics is the new trend, but I don't think it is for the majority of existing modern interfaces. Not unless manufacturers are willing to offer training and priority support, just as uAvionix is promising with its proposed non-avionics-shop install network. Still, if you're contemplating having a mandate-compliant ADS-B system installed by an A&P, caveat emptor. The installation will still need to be tested and if it's a 1090ES transponder, it will require an FAR 91.413 ATC transponder test and inspection. Don't be surprised if the installer sends you to an avionics shop to have that accomplished because the majority of A&P/IA mechanics don't have the necessary test equipment to do the check.

Last, AEA's Ric Peri made a good point that without some training, not all A&Ps will be qualified to do an ADS-B install. Buyers should select them carefully. *—Larry Anglisano*

VORTEX GENERATORS

Thank you for the article on VGs in the March 2019 issue of *Aviation Consumer*. I own a 1979 Cessna 172XP, which I have been updating for performance and especially safety. I have so far added a glass cockpit, engine monitor, an upgraded engine and four-point seat belts. My next focus is on slow-speed flight. I couldn't agree more that this will be an important safety feature. My biggest question now is whether to pursue VGs or a STOL kit, and whether there is a difference between manufacturers.

As you might surmise, there is a lot of opinion out there on that subject. You seem to be implying in your article that VGs would be a preferred choice over a STOL kit, but you didn't actually say that. From your experience, if you were in my shoes, and money wasn't the single most important consideration, how would you proceed and why? You would certainly make my day if you can answer this question.

Rod Kleiss
via email

Having flown aircraft with STOL kits and aircraft with VGs, as well as a few with both, our opinion is that when deciding between a STOL kit and VGs, the VGs are the better option. That's because they weigh so much less and give just about the same performance improvement as a STOL kit. We're not convinced any difference in stall speed reduction between VGs and a STOL kit on a 172XP would be measurable. It could be lost in measurement error. If fact, with either a STOL kit or VGs, you start getting into a situation where you can fly yourself into a field from which you couldn't depart.

We do note that VGs and STOL kits allow you to fly the airplane so slowly that it can take nearly full power to maintain level flight—which can be unpleasant if you get low and slow on final. We had a white-knuckle experience when having to use full power to make it to the runway in a Cessna 206 when a downdraft on final was stronger than expected and wound up with the stall horn sounding a quarter mile from the runway.

VGs and STOL kits will reduce stall speed, but they also mean that you can fly the airplane into a region of very high drag near the new, lower stall speed. That means you must be prepared to deal with a very high sink rate and a demand for a carrying a great deal of power to hold altitude or stay on the glide path.

As to which VG kit, we think so long as the kit includes VGs for the underside of the horizontal stabilizer (for effective elevator control at low speeds) and both sides of the vertical stabilizer (for rudder control), you won't go wrong no matter which manufacturer you select.

TUNED EXHAUSTS

I read with interest your article on exhaust systems in the February 2019 *Aviation Consumer*. For the tuned exhaust market you hit the longtime player with Power Flow.

However, you missed the fairly new entrant in the market with D'Shannon Aviation. Power Flow has been promising for years to do a Bonanza version and we're still waiting, but D'Shannon has a Bonanza tuned exhaust system today.

Alan Williams
via email

UAVIONIX LIMITATION?

I am interested in installing a uAvionix skyBeacon ADS-B Out unit on my airplane. It is appealing because it also contains a wingtip strobe. However, I noticed in the installation guide on page 11 that the GPS in only certified for en route and terminal airspace and it is not approach certified.

What are the ramifications, if any, for instrument approaches in class C airspace be it a GPS, VOR or ILS approach?

Norm Andre
Downers Grove, Illinois

Good catch. We asked uAvionix for an explanation. It told us this limitation means nothing for real-world operations. Because the WAAS GPS in the skyBeacon is only connected to ADS-B and not an autopilot or any other navigation system, there is no need (or really any ability) to change between approach modes.

The company says the device meets all GPS requirements in any aircraft flying any type of operation, from an Airbus A380 to a Piper Cub, but the way the TSO is written, the company is required to point out that you can't fly an approach using the unit's built-in WAAS GPS as your guidance source. You can, of course, use it as your ADS-B Out position source during that approach, however.

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On The Cover: That's a Cirrus Certified Preowned SR22 that was refurbished by Lone Mountain Aviation in Las Vegas, Nevada. With so many worthy Cirrus models on the used market, we took a fresh hard look at the fleet's safety record. The results are in the field report starting on page 4 of this issue.

AIRCRAFT SAFETY REVIEW

Cirrus at 25: A Safer Airplane?

Data trends suggest that it is. The fatal accident rate is below average and CAPS has delivered. But serious landing mishaps still bedevil owners.

by Paul Bertorelli

The year was 1994. At Oshkosh, a small kit airplane company whisked the wrapper off a four-place, fixed-gear composite airplane called the Cirrus SR20. Weeks of tantalizing promotion promised that the airplane, hidden in the shadows of "Hangar X," would be nothing less than the future of aviation.

A quarter century later, it's fair to ask: Well, was it? The easy answer is yes, it was and is. But with a host of safety features such as crashworthy seats, energy absorbing structure, cabin flail space and the first-ever certificated airplane ballistic recovery parachute, Cirrus also implied that its new airplane would be safer, without actually saying the safest ever. So, how about that? Has it delivered on those claims? Answering that is not as simple as crunching the GAMA numbers to enumerate Cirrus' inarguable dominant market share. But with a quarter century of accident data to review, it's reasonable to take a stab at it.

At the outset, two things are apparent: For the past five years, the Cirrus fatal accident rate has trended downward and the company has responded to an exceptionally activist owner association to improve safety-related training for its customers.

2018
0.78
FATAL ACCIDENTS PER 100,000 HOURS

2012
1.60
FATAL ACCIDENTS PER 100,000 HOURS

ALL THE ACCIDENTS

For this report, we reviewed all of the accidents recorded in the NTSB database and relied in part on data provided by the Cirrus Owners and Pilots Association. Among all the owner groups, COPA is exceptional for maintaining an active watch on accidents and especially use of the Cirrus Aircraft Parachute System, or CAPS.

Cirrus confirmed total hours-flown data but declined to release yearly data. We reviewed every available accident report, some in detail. At the outset, two caveats: First, there's some apples-to-oranges in the numbers because Cirrus and COPA maintain worldwide fleet hours-flown data and we concentrated on U.S. accidents because the NTSB site offers the most detail on these.

Second, small-numbers syndrome complicates drawing grand conclusions from swings in accident incidence. For example, even with a million fleet hours a year, two or three additional fatal accidents move the rate needle measurably. This is why COPA uses a three-year rolling average and why we encourage parsing the macro trend lines, not spikes for individual years.

LOWER RATES

COPA's data—not independently confirmed by us—reveals a three-year fatal accident rate of 0.78/100,000 hours through 2017. Depending on whose wider GA data you prefer, that's right at or slightly below the general aviation average, which has itself been declining. (The NTSB pegs the fatal rate at 0.98, while AOPA's Nall Report places it at 0.80.) The overall worldwide accident rate for Cirrus from day one is 3.5/100,000 compared to Nall's recent 4.92 for GA in general.

The decimals are less important than the trend direction and for Cirrus overall and fatal rates, the trend is south. When we last examined the Cirrus safety record exhaustively in 2012, we calculated a fatal rate of 1.6/100,000, which was slightly higher than the then-GA average of 1.2. At that time, the Cirrus fleet's overall accident rate was about half the GA number.

A spate of early Cirrus fatal accidents—duly covered by an aviation press that found them novel—gave the impression that the aircraft had a poor safety record. Owners we surveyed (see page 7) told us as much. Yet the accident rates weren't so much horrible as disappointing. Given the Cirrus design ethos, they were expected to be better. *Much* better. Our 2012 review found that the Piper Saratoga, Mooney M20

DATA ANALYSIS

TALE OF THE TRENDS

These graphics summarize the Cirrus SR20/22 accident trends from day one. The blue line represents aircraft population with the values depicted on the left. (Although the green all-accidents line appears above the aircraft population trace for the SR22, this is a limitation of the chart design and doesn't mean crashes outpace production.)

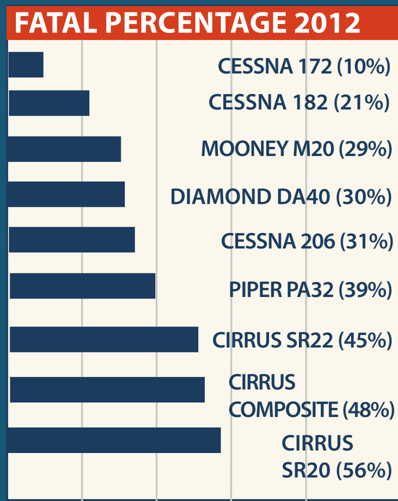
A key takeaway is the red fatal-accidents trace. Despite some spikes, the directionality is essentially flat, which confirms a declining fatal accident rate because as more aircraft entered service and more hours were flown, raw numbers of fatal crashes haven't increased.

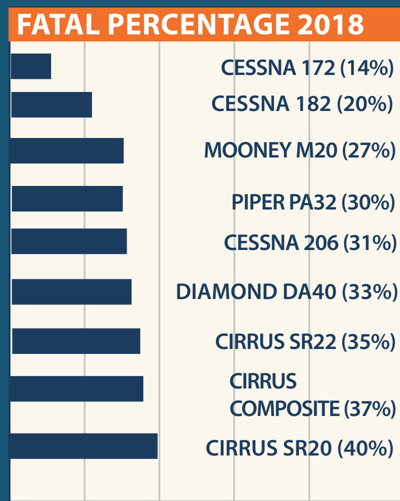
This is further confirmed by the percentage of accidents that were fatal, as depicted in the top charts. During the six years since we last examined Cirrus accident rates in 2012, the percentage of Cirrus crashes that were fatal has declined significantly for both models. Other aircraft we examined have remained relatively stable.

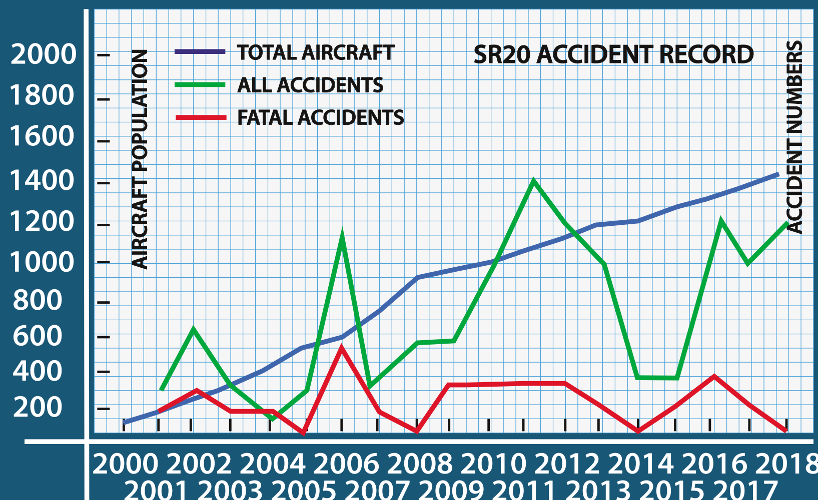
Total accidents are a different story, especially for the SR22. The green trace is spikey for the SR20 and shows a sharp rise after 2015. However, SR20 accident numbers have still been relatively stable as the fleet has grown. For the 18-year period we examined, the SR20 has averaged 1.2 fatal accidents per year.

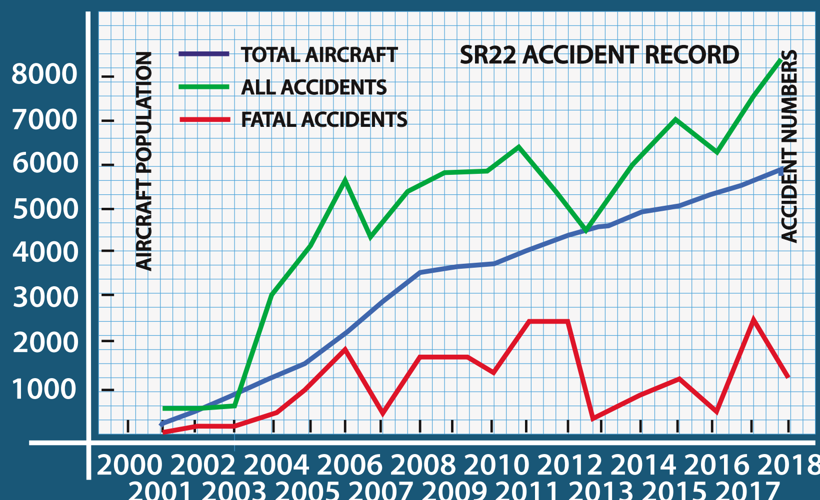
Total accidents for the SR22, on the other hand, have trended upward since 2013 and reached a record peak of 20 total U.S. accidents in 2018. Only four of those accidents were fatal, which is in line with the 18-year average of 3.6 fatals per year.

If the Cirrus worldwide fleet hours-flown claim of a million hours per year is accurate, the worldwide overall accident rate for 2018 was 2.7/100,000 hours or less than half the 4.92 GA average. But the worldwide fatal rate just for 2018, at 0.6/100,000, is lower than the 0.80 GA average and lower than COPA's 0.78 three-year rolling average, a trend that may or may not sustain.









CIRRUS ACCIDENT CAUSES

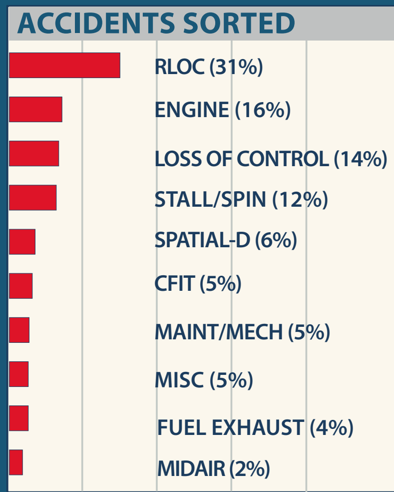
As shown at right, landing-related accidents play an outsized role in the Cirrus accident picture. We're not sure if the Cirrus line has the highest incidence of runway loss-of-control (RLOC) accidents, but our long-term reviews of other aircraft find that the Bonanza and Cessna singles and retracts have a lower RLOC percentage. By model, Mooneys are sometimes comparable.

What's relatively unique about Cirrus RLOCs is that they seem to occur at higher speeds and significantly damage the aircraft. While injuries aren't common, we found at least a dozen that did involve slight to moderate injuries and one fatality. To be fair, we found similar accidents with other types, but they aren't as numerous.

Complicating characterizing this accident type is that many involve a hard touchdown, followed by a go-around that goes bad because the pilot fails to counter the engine's strong torque at low speed, causing the airplane to roll and catch a wing. These are often found on the left side of the runway. Some are described as stalls.

Speaking of which, despite the Cirrus stall-resistant split-incidence wing, the type does have a stall/spin presence. A handful of these were base-to-final turns; some were on departure or on some phase of the approach.

Otherwise, rounding out the Cirrus accident pattern are the usual suspects. Loss of control is garden variety upsets in turbulence or due to pilot distraction. More than one of these was saved by a CAPS deployment and the pilot lived to tell about it. Spatial disorientation as a cause appears to be comparable to other models, but again, the CAPS saved the day in some of these, where it is nearly always fatal in other models.



series and Cessna 206 had the same or higher fatal rates. If there was an inflection point in the Cirrus accident history, it would have been in 2011, when there were 16 fatal crashes worldwide—five in one two-week period in November and two on one day. Prior to that, in 2010, COPA's accident data guru, Rick Beach, had discovered that many Cirrus fatals could have been prevented if pilots had simply used the parachute.

If we had a wish list for Cirrus aircraft, it would be better protection of the fuel. Post-crash fire is frequent, as it was in this crash. The pilot stalled after an aborted landing.

COPA sources are carefully politic in describing Cirrus' reaction to Beach's not-entirely-joking "pull-early-and-pull-often" urging, but 2011 convinced the company it had to act. Cirrus made a video extolling the virtues of CAPS that owners see yet today as part of their factory training. By then, Cirrus had already upgraded its training twice, eventually pulling it entirely in-house. All new-aircraft buyers take it. More recently, it launched Embark, a unique free factory-supported training program for all owners buying Cirrus aircraft on the used market.

CAPS use has put measurable downward pressure on the Cirrus fatal accident rate. There were 10 activations in 2018 alone, most of which might easily have been fatal accidents instead.

UPTRENDS

Although we don't consider yearly accident spikes useful metrics, we did ask Cirrus and COPA about the elevated number of total SR22 accidents in 2017 and 2018, even as fatals remain low. If there's a unified theory here, it has to do with buyers on the used market who, despite Embark, might not be seeking competent training.

"A factor that's relevant is the turnover of these aircraft in the used market. In any year, you might be introducing 500 or 700 or 1000 new-to-the-type pilots into the fleet. Time in type is a significant factor. Those are higher-risk hours," says Rob Haig, director of flight training at Cirrus. COPA's Beach and long-time Cirrus instructor Trip Taylor made the same observation. Taylor is the incoming president of COPA. (For reference, 13 of the 25 accident aircraft in 2018 that we found good data for were 10 or more years old.)

We asked if selling Cirrus airplanes into an ever-expanding market inevitably stretches the aptitude envelope. "Yes, that resonates with me, but it all also may be confirmation bias. We may be eating our own dog food on that," Taylor says. Further, Haig said the aging fleet means used prices are more affordable, potentially broadening the market base and while that brings in new owners, it also brings in inexperience.

"One shift that has been interesting to me is that I used to do a lot of instrument ratings. That has been supplanted by doing private pilots, which is not something I have done much of in the Cirrus," Taylor adds. Cirrus anticipated this and that's why it launched Embark.

Haig thinks Cirrus has good market penetration with Embark, but the company has no hard data on uptake. "I do have the sense," adds Haig, "that the used aircraft buyer is more sensitive to things beyond just the price of the aircraft." And feedback from the field suggests that may include not hiring a Cirrus-trained instructor for the checkout. Cirrus has about 400 factory-trained Cirrus Standardized Instructor Pilots around the world and 90 Cirrus pilot centers. "With Embark, we want to take cost off the table," Haig says.

LANDINGS

Our survey revealed that the majority of Cirrus owners don't think the airplane is difficult to land, although a few told us they thought the airplanes have landing issues. Trip Taylor, with some 15,000 hours of Cirrus time, much of it instructing, says the Cirrus line's landing accident pattern isn't much different from that of other aircraft. "However, I would characterize the Cirrus as marginally more difficult to land than some in its cohort," he adds.

Moreover, when Cirrus landings go bad, they sometimes go very bad, with serious damage to the airplane and sometimes injuries. "There are a number things that come into play. One is the sight picture. Pilots aren't used to how it looks because the visibility is so good over the nose. As a result, they

CIRRUS OWNER VOICES

When the Cirrus success story is analyzed, a favorite journalist question to aircraft salespeople is this: Is it the parachute that closes the deal? The answer is simple: Yes, sort of, maybe, sometimes, no. Or so owners tell us.

As part of our 25-year look back, we heard from about 80 owners we invited to answer survey questions. Their opinions are all over the map but if there's a general trend, it's that early buyers often didn't think much about it, but more recent buyers do and, interestingly, second- and third-time buyers tend to mention CAPS as a factor.

"The Cirrus had no safety record when I purchased the SR20 in 2000. I was attracted to its safety features, including CAPS, energy absorbing gear, seats and side stick. With my purchase of a 2018 G6, I am convinced I am safer in a Cirrus than any other comparable aircraft," said John Evans.

"If anything, in 2014 I was a bit leery of the Cirrus safety record. At that time, I didn't care about the parachute," wrote Dan Montgomery. Now, he says, he can't imagine flying without CAPS.

Another common thread is the oft-cited spouse factor. "The wife liked the CAPS idea," said owner Jim Anderson. Hearing that, an aircraft salesperson trying to nudge a buyer to yes will know which buttons to push. "One of the most common thoughts of non-pilots who fly with me is 'what do I do if he passes out?' Now I can brief them on exactly what to do and chances are they will be OK. I plan to do a CAPS sim session with my wife," said Australian SR20 owner Andrew Jeffreys. We also asked about CAPS and risk homeostasis—the theory that having a free get-out-of-a-jam button in CAPS encourages pilots to take more risks. "Good question … I think most owners would say 'absolutely not ' because we don't want to give the Cirrus haters ammunition. But in, reality, maybe," said Brent Forman.

And he's right. The majority of owners said having the CAPS handle available absolutely, positively, no-way, no-how causes them to assume risks they otherwise would not. But COPA's Rick Beach says he's in the maybe camp by degree. "I follow roads was my go-to plan during primary training, but with CAPS reliability, I flew higher and more direct over less inhabited and hence more inhospitable terrain. No change in weather decisions," Beach explains.

As our data show, landing accidents loom large in the Cirrus accident pattern, but a couple of caveats: Depending on how the data is sorted, this is also true of other models, but the numbers are small. Still, landings are enough of a concern for both COPA and Cirrus to have focused efforts on reducing the incidence.

Our survey revealed that most owners don't see the Cirrus airplanes as difficult to land. "I do not find the Cirrus difficult to land or land well," said Scott Hopkins, "but it does take more attention than a 172 or a Cherokee. We operate out of a 2700-foot airport without difficulty. I would advise new owners to check the nosegear pucks and to pay attention to speeds and crosswind inputs."

Said Samir Kanuga, "I believe it's not the landing that's the issue, it's the approach. You must have a stabilized approach. Airspeeds into the arrival corridor are much higher than for training aircraft. You need to plan the arrivals so you are not cruising through the pattern at 170 knots, then no issues."

misjudge the flare quite frequently. They're higher than they think they are," Taylor says. That can lead to a hard touchdown, a bounce and loss of control.

"I think the more pernicious scenario is that the very same pilot on the next try may land too flat, so all three wheels touch at the same time or unfortunately the front touches first. And that sets up the classic pilot-induced oscillation," Taylor explains. If the go-around isn't handled right, the airplane gets slow and when power is applied sans rudder input, the aircraft rolls. "And it will always be found on the left side of the runway," Taylor says.

"The gear is a little springy and that aids in launching the airplane. I wouldn't call it a design flaw, but it's a characteristic that we need to make our pilots aware of," he says. The worst version of this is a go-around that gains enough altitude and/or speed to clear the runway, but then collides with obstacles, stalls or rolls. Taylor believes pilots can be trained to land the airplanes safely, but it's better done by CSIP instructors familiar with the challenges. COPA tracked a series of seven accidents in which pilots had been trained by non-CSIP instructors. COPA's in-house accident data show that its members have a lower fatal accident rate.

CONCLUSION

Following the 2012 embrace of liberal CAPS doctrine with training that encouraged it to be considered as the first emergency response rather than the last resort, the Cirrus fatal accident rate dropped measurably. As the fleet ages and older airplanes become more affordable, Cirrus faces the challenge of not becoming a victim of its own success. While a stall-resistant wing, crashworthy seats, envelope protection and CAPS are powerful safety features for Cirrus, COPA's Taylor views them as merely raw material.

"They simply don't help you unless you understand how to manage all those things," he says. In our view, Cirrus deserves credit for responding to COPA's trend tracking and especially for Embark. If used buyers new to the type use it, they have a better chance of avoiding an accident.

Instrument Repairs: Still Cheaper Than EFIS

But for complex instruments facing obsolescence, upgrading to solid-state glass makes better sense. Think long-term and consider the warranty.

by Larry Anglisano

With primary EFIS hardware prices at an all-time low, you'd think the decision to not repair old iron gyros and static instruments would be easy. It's not. That's because budget systems like a pair of Garmin G5s and Aspen's entry-level E5 PFD could still run north of $10,000 after installation. That's still out of the budget for many.

The fallback, of course, is repairing/overhauling old instruments that may be left over from the Reagan era. This may or may not make sense, depending on the supportability, reliability and bottom-line cost for the work. In this article we'll look at the market for instrument repairs and exchanges, while offering tips for deciding whether an EFIS upgrade is the better decision.

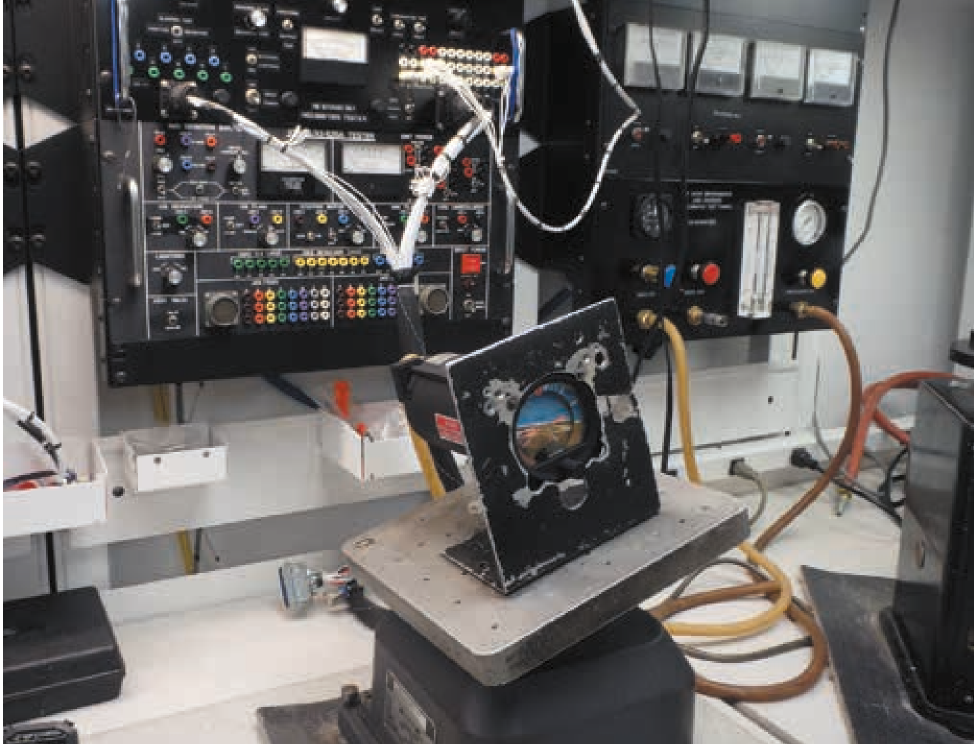
WHERE SHOULD YOU GO?

When faced with any instrument problem, most owners leave it up to an avionics shop or even their mechanic/repair shop to handle the repair—from removal to reinstallation. We think the owner should be more involved in the process. There are more considerations than you might think, and there's more to instrument repairs than the physical bench work.

Aside from troubleshooting and verifying that the failure is contained to the instrument (there could be a pitot/static system problem or issues with the vacuum system), whoever is handling the repair will have to decide where to send the instrument. That's because the typical avionics shop won't have instrument bench repair capabilities, and the repair

A technician at Mid-Continent Instruments and Avionics works with a Century NSD360A vacuum-driven HSI in the main image above.

Instrument repair and overhaul require specialized bench equipment. That's a gyro tilt table at VIP Aero Instruments and Avionics in Connecticut. Most every round-gauge instrument in the Piper panel, middle, should still be well supported by competent instrument shops. Autopilots like the KAP140, bottom, rely on a turn coordinator for roll input.



will be farmed out to a qualified (hopefully) instrument facility. These instrument shops should have the qualifications to accurately represent the work per the regulations. It's easy to trick up the wording when it comes to rebuilding and overhauling.

FAR 43.2 says, in part, that no person may describe in any required maintenance entry or form a component being rebuilt unless it has been disassembled, cleaned, inspected, repaired as necessary, reassembled and tested to the same tolerances and limits as a new item, using either new parts or used parts that conform to new part tolerances and limits. To sign a component off as being overhauled, nearly all of the above applies, except testing it to new part tolerances. That might not always happen.

For example, properly overhauling a gyro includes replacing the bearings and any worn mechanical parts. It also includes disassembling the rotor assembly, while replacing any worn parts in it. Autopilot interfaces make the entire process more complex, often requiring additional work when the instrument is reinstalled because it should also include calibrating the electronic outputs.

In the case of many autopilot gyros, you'll pay additional shop labor because there might be fine adjustments for the proper autopilot bank angles, roll rates and flight director command bar presentation. Performing this alignment could be the difference between an autopilot that flies perfectly or one that's sloppy. It may even require flight testing to make sure the adjustments are correct.

CHECKLIST

- (+) Even the most expensive instrument overhaul is cheaper than an EFIS upgrade.
- (+) An overhaul/exchange instrument will get you back in the air quicker.
- (~) Still, that money may be better spent toward more reliable EFIS technology.

THE WILD WEST

That's how some describe the instrument repair and overhaul business because, frankly, some shops have no business attempting repairs for lack of current manuals and approved service parts. Plus, a simple repair may only be a temporary fix, and performing a zero-time teardown overhaul may be money better spent on the front end. That's often the case for air-driven instruments.

"For these instruments it's usually not economical to simply replace a couple of the gimble bearings, given the level of teardown that's required to gain access. We feel we're not providing the customer a good service by charging them for half of an overhaul when we just don't know how long the rotor might last," said one instrument shop manager.

David Copeland at Mid-Continent Instruments and Avionics (which has locations in Kansas and in California) told us that the majority of instruments it reworks and sells are completely overhauled. "Sometimes that's a problem for the customer because the overhauled instrument

Some instrument failures require deep troubleshooting. The King KI525A HSI, top, is driven by the KG102A remote heading gyro. The red arrow points to the component in the nose of a Baron, bottom. Still, each of these instruments could set you back $2000 for an overhaul or exchange.

aesthetically looks better than any of the other instruments in the panel," he said, tongue in cheek. Quality shops like Mid-Continent might send out fresh instruments with new glass and repainted bezels and casings, for example.

The other thing to consider is the instrument's warranty, which may tell a lot about the quality of the overhaul. Typically, a repair is covered for 90 days and only includes the work performed during the repair. The standard instrument overhaul warranty is generally one year. You could spend $150 on a basic repair today, but might ultimately have to pay for a $500 overhaul next week, for example. That's why for basic instruments, we think an overhaul makes the most sense—especially while the instrument is opened up. But not every instrument may be eligible for overhaul. Its vintage and version may have obsolete parts. This is problematic if you're trying to get back in the air in short order. Mid-Continent's Copeland told us that the typical turnaround time may be five to 12 days, but an exchange will obviously be a lot quicker and oftentimes the best option if you don't care about getting your specific instrument back. There are a few snags many don't think about.

It's important to note that even if your instrument is still supported, it might not be eligible for an overhaul or exchange. If the instrument is missing a data identification tag (listing the original part number and serial number), you could get stuck with buying a new instrument outright. Similarly, if the removed core is found to have excessive corrosion or damage, it will likely be rejected as an acceptable core.

OBSOLETE INSTRUMENTS

In some cases the instrument may simply be too old to do anything with, and this includes vintage attitude instruments and altimeters. This means you'll probably have to buy an outright factory new replacement, with no core credit offered.

There are options. Two industry-standard brands—Sigma Tek and United Instruments—were suggested by every shop we spoke with. If you're faced with replacing an old obsolete airspeed indicator, you'll likely have to order a new United model and rest the old one on your bar shelf as a conversation piece. Several shops told us there's no support for some original-equipment Piper and Beech models. The shop needs the airspeed range marking data from the aircraft flight manual to set up the new instrument appropriately.

As for gyros, Sigma Tek offers a variety of replacements, including models with vacuum warning flags, internal lighting and heading reminder bugs for directional gyros. The company also offers models that will drive the heading command function on autopilots.

Speaking of autopilots, there might be more interface to your system than you realize, and the vintage round-gauge instrument you want to ditch in favor of a newer model might have to stay because it's integral to the interface. Some autopilot altitude preselect systems, including models from S-TEC, BendixKing and Sperry, rely on the encoding altimeter for a baro source input. Even the turn coordinator could still be required, since it drives most Genesys/S-TEC rate-based autopilots. The same goes for the BendixKing KAP140 system. For the majority of buyers, this isn't a deal breaker, but it complicates new panel layouts and won't alleviate the high cost of instrument maintenance—a driving factor for upgrading in the first place.

Some stuff might finally be

retired. This includes just about anything made by Narco Avionics, including the DGO-series HSI. But others, like the King KCS55A slaved compass system with HSI, may be worth saving, but get ready for a big invoice, and some troubleshooting along the way. We get lots of calls here at the magazine from readers looking for troubleshooting advice for this system, especially when they take it to shops that aren't experienced in working on the system. It's complex.

Consider that troubleshooting basic gyro instruments is easy—if it tumbles or is slow to erect it's probably time for overhaul. But diagnosing the multi-piece Bendix King KCS55A slaved HSI system isn't. We've seen many a hasty shotgun approach to component replacement cost owners thousands of dollars, and in some cases not even fixing the original problem.

You might start the repair process by understanding the system and doing some basic troubleshooting of your own before you show up at the repair shop. The venerable KCS55A is generally a reliable system, but as the fleet of KCS systems age, shops are seeing more subtle failures that can be difficult to accurately diagnose. It's a challenge because there are four major remote components in this system, including the KI525A HSI, the KG102 remote heading gyro, the KMT112 magnetic flux sensor and KA51 slaving accessory.

A common failure mode might include heading error, where the system doesn't accurately keep up, despite the built-in slaving circuitry that's designed to correct for natural gyro precession. It's natural to assume the problem exists in the remote gyro, and it often does, but there could be a problem in the HSI itself, perhaps binding in the gears that drive the heading card. An experienced shop should ask you some basic operational questions. Does the system fail while in free-gyro mode or only in slaved mode? To find out, select the free gyro mode on the panel-mounted slaving control. You'll need to correct for some gyro precession by slewing the system to the proper heading, just as you would with a conventional directional gyro. When the system is showing a heading error, is the heading flag in view? You'll want to be armed with the answers to these questions before showing up at the shop—especially the wrong shop—which might shotgun expensive components without doing the right troubleshooting.

Which fails first, the vacuum pump or the instrument? That's tough to say, which makes upgrading to Aspen's all-electric PFD, bottom, worth considering. The E5 PFD shown in that photo has an STC that allows for removal of the vacuum system.

THE EXTRAS THAT ADD UP

Don't underestimate the cost of shipping when your shop farms out an instrument repair. Fragile gyroscopes need to be shipped in larger containers to keep them safe during transport. The resulting costs can add hundreds of dollars to even basic instrument maintenance. If you're in a hurry to get the instrument out and back, freight costs can be shocking. Labor costs can be hefty, and some aircraft are simply easier to work on than others.

Reader Jim Simpson told us of the labor effort his shop billed out for removal and reinstallation of the BendixKing KI256 flight director gyro in his Cessna P210. "In addition to the $2388 flat-rate overhaul cost of the gyro, the invoice included $183 in freight (to and from the instrument shop) and $990 in labor," he told us. When he questioned the shop about the charges he was told it took nearly two hours to disassemble and reassemble the panel, and the rest was nulling the gyro's outputs to properly drive the KFC200 autopilot that it's connected to. This included roll and pitch adjustments, plus adjustments to the command bar presentation. "Had I known I would be into this old thing for close to $4000, I would have considered a glass upgrade," he told us.

Another gotcha could be hid-

TYPICAL OVERHAUL COSTS AND RECOMMENDATIONS

TYPE	MODEL	COST	COMMENTS	SUGGESTION
ALTIMETER	5934-A74	$500-$750	UNITED 20K FEET	OVERHAUL OR EXCHANGE
ALTIMETER	102200	$1200	ALTITUDE ENCODING	INSTALL ENCODER,STD ALT
ATTITUDE GYRO	5000B-36	$800	STANDARD SIGMA TEK	OVERHAUL OR EXCHANGE
ATTITUDE GYRO	52D66	$1000	CENTURY AUTOPILOT	OVERHAUL OR EXCHANGE
TURN COORD.	1394T100-7Z	$750	STANDARD ELECTRIC	NEW EXCHANGE
TURN COORD.	1394T100-14RB	$1500	S-TEC AUTOPILOT	NEW EXCHANGE
DIRECTIONAL GYRO	KG102A	$2000	B/K REMOTE ELECTRIC	EVALUATE FOR REPAIR
DIRECTIONAL GYRO	4000B-30	$900	A/P HEADING OUTPUT	OVERHAUL OR EXCHANGE
HSI	KI525A-01	$2000	KING WITH SYNCHRO	EVALUATE FOR REPAIR
HSI	NSD360A	$3000	CENTURY SLAVED	EVALUATE FOR REPAIR
VSI	7000C	$450	UNITED 0-2000	IF PFD-EQUIPPED, REMOVE
AIRSPEED	8000-XX	$1000	CUSTOM MARKINGS	NEW OUTRIGHT

ing inside the case of an encoding altimeter. These are altimeters that also house a Mode C altitude reporter. Our advice is to pay particular attention to the health of these instruments during the two-year pitot/static/transponder certification. In for an ADS-B upgrade? Have the shop evaluate the altimeter's health.

You might even consider replacing the instrument altogether. That's because the cost of overhauling or replacing a standard altimeter could be half the price of a combination unit. To reduce these maintenance costs, you'll have to spend some money up front. The installation of a new altitude encoder might cost $400, in addition to the cost of a new United altimeter that averages around $1000.

Plus, if the altitude encoder inside the altimeter fails, the shop won't be able to sign off the altimeter portion during the two-year inspection because the regs suggest that all of the instrument must be functional, not just a portion of it.

A LUKEWARM CASE FOR GLASS UPGRADES

The pricing chart above supports the idea that you should at least get a couple of quotes for a primary flight display (PFD) when faced with an instrument overhaul. As we've been reporting, entry-level systems from Garmin (the G5 AI and G5 DG) and Aspen (the Evolution E5 PFD) are priced around $5000, but the retrofit will likely top $10,000 after installation. That's better than $20,000, which is where the numbers fell before Garmin and Aspen brought non-TSO solutions to the market. But not all potential buyers are sold on $10,000 glass upgrades.

In a recent survey on sister publication *AVweb*, 34 percent of respondents said they would at least get a proposal for a budget glass upgrade, 27 percent thought that a $10,000 EFIS buy-in was overpriced, 29 percent thought the price was fair given the capability and 10 percent said they weren't even installing ADS-B.

That pretty much jibes with what shops told us, reiterating that many buyers faced with instrument repairs (not necessarily those who would spend a lot more for high-end upgrades) are interested in a Garmin G5 or Aspen E5, but a good percentage end up keeping legacy instruments, at least for the short term.

David Copeland at Mid-Continent sees that exact trend and as a result, the company is stepping up its efforts to source more core units so it has a larger supply of instruments on hand and ready to ship. Mid-Continent supports over 6000 models of instruments and avionics, including autopilot servos.

"Over the past 18 to 24 months,

continued on page 32

Warranty Coverage: Read the Document

Whether it's a new airplane, new avionics or just putting your airplane into the shop for maintenance, know what the warranty covers.

by Rick Durden

It's been heard ever since commerce began: "I want my money back!"

You bought something and now it doesn't work. What recourse do you have? Can you compel the seller to exchange the bad something for a new one? If you return it, are you entitled to a refund of the full purchase price? Will the seller pay the full cost of getting it fixed? What if the something is three months old? A year? Five years? How long is the seller obligated to repair a defective product, exchange it or take it back and refund your money?

While the odds of a reader of this magazine buying a new airplane this year are low, the odds that that same reader will be buying new avionics (ADS-B, remember?), having an engine overhauled or having the family airplane upgraded in some fashion approach unity. That means that you may be faced with a problem with the new something on your airplane and you'll want to get it fixed without having to shell out any more money. That brings us front and center to a discussion of warranties, what they are, what they require a manufacturer or seller to do and how they can be limited to restrict the buyer's rights when something does go wrong.

BACKGROUND

We'll start by pointing out that warranty law varies from state to state, so if you wind up in a fight with a seller, you're going to need to look to your state laws to find out the specifics as to the rights you have. That being said, the state laws regarding warranties are more alike than different, so it's worth going through a discussion of warranty law generally—while pointing out that this article is not legal advice and that you should consult a lawyer who knows your state law on warranties should you get into a big disagreement with a seller.

The underlying notion behind warranty law is that when someone makes something and sells it, or fixes a broken something, that maker/seller/repair shop makes an implied warranty that the something will do what it is supposed to do—and keep doing it. If it doesn't do what it's supposed to do, the maker/seller/repair shop is obligated to stand behind its work—either take the product back and return the buyer's money, fix it or replace it with another product that does what the first one was supposed to do. For how long? A "reasonable" period of time.

The problem is obvious—lack of certainty. For the buyer it's uncertainty as to what he or she is going to get if the aircraft breaks or the maintenance didn't fix the underlying problem. For the builder/seller/repair shop, it's uncertainty regarding what it will have to do if the product breaks and for how long.

LIMITED WARRANTY

One of the most effective ways to kill off business is to introduce uncertainty—and an implied warranty means major uncertainty. State laws long ago evolved a way to wipe out most of the uncertainty in the warranty world. The laws allow the builder/seller/repair shop to limit its repair/replace/refund obligations by providing the buyer a written warranty that clearly states what it will and won't do when the product doesn't work.

A written, limited warranty also sets out what the buyer must do to take advantage of the written warranty should something break.

The written warranty becomes part of the agreement the buyer makes with the builder/seller/repair shop when the buyer buys an aircraft or component or has

LYCOMING

WARRANTY

NEW AND REBUILT RECIPROCATING AIRCRAFT ENGINES

(1) WARRANTY: Lycoming Engines, a division of Avco Corporation (hereinafter "Lycoming") warrants each new and rebuilt Lycoming reciprocating engine to be free from defect in material or workmanship under normal use and service for a period of twenty-four (24) months or the recommended engine time (hours) between overhauls ("TBO") in accordance with the latest edition of Lycoming Service Instruction 1009, whichever occurs first. Lycoming's sole obligation under this warranty is limited to replacement or repair of parts which are determined by Lycoming to have been defective within the warranty period. The warranty period commences on: (a) the date of first operation after new aircraft delivery to the original retail purchaser or first user; or (b) twenty-four (24) months from the engine ship date from Lycoming, whichever occurs first.

(2) HIGHLY UTILIZED ENGINES / LYCOMING LOYALTY PROGRAM WARRANTY: Additionally, Lycoming also warrants the crankcase, crankshaft, cylinders*, sump, accessory housing and all internally lubricated parts to be free from defects in material or workmanship under normal use and service for an additional twelve (12) month period from the warranty period applicable in (1) above on highly utilized engines that consistently accumulate forty (40) or more flight hours per month. This additional twelve (12) month warranty period is limited to new or rebuilt engines purchased on an exchange basis in accordance with a Lycoming Loyalty program through an Authorized Lycoming distributor.

(3) REMEDY: Within the warranty period, Lycoming may reimburse the purchaser for (a) parts; (b) prorated engine replacement; (c) labor; and (d) freight associated with warranty related issues.

(3)(a): Warranty replacement parts installed on engines which are covered by this New and Rebuilt Engine Warranty will be warranted for the balance of the original engine warranty period. At Lycoming's sole discretion, warranty replacement parts may be either new or reconditioned. A claim for warranty must be reported in writing to an Authorized Lycoming distributor within 30 days of any suspected defect in material or workmanship. Warranty is contingent upon the purchaser complying

A portion of Lycoming's new and rebuilt engine warranty.

WARRANTY OR INSURANCE? TRAPPED IN THE GAP

In 1997, Joel Rosenlicht bought a 1979 Cessna P210. He flew the pressurized single for 10 years before taking it to O & N Aircraft for its Silver Eagle mod. Five months and $770,000 later the original 310-HP Continental TSIO-520 had been replaced with a 450-HP Rolls-Royce 250-B17F turboprop engine and the airframe had been significantly modified to handle the additional power. The result was a truly high-performance single that cruised over 200 knots in the flight levels and could safely use grass runways—capabilities that Rosenlicht needed for his business.

Over the next 11 years, Joel flew his Silver Eagle extensively. He told us that it met his needs almost perfectly. He had the annuals performed at O & N Aircraft and then at Griggs Aviation when it took over the Silver Eagle STC after the death of O & N's founder.

In May 2018 chip light #3 illuminated three times in 10 hours of flight. The engine has three chip lights that correspond to chip detectors in three locations in the engine. The engine was inspected after the first two chip light events and a small bit of metal was found. After the third, Griggs Aviation recommended that the aircraft be brought to them for further inspection.

Chris Murley of Griggs told us that, in consultation with Keystone Turbine Services, the engine was pulled and sent to Keystone for evaluation.

Because of the location of the chip detector that had flagged metal in the engine, the gearbox was opened up. Inside, techs found a half-inch polishing stone, sometimes called polishing media, with a gouge in its side. The stone was the sort that was used to polish gears during the manufacturing process. Because the gearbox is essentially a sealed unit, it was likely that the stone had been in the gearbox in a benign location for 10 years before it shifted and started causing damage to components within the gearbox.

At that point things started getting confusing. In consultation with his insurance broker, Rosenlicht made an insurance claim. According to Rosenlicht, his insurer initially indicated that it was going to pay the claim and subrogate against Rolls-Royce. However, as time went by and more and more people, including the FAA and Rolls-Royce, got involved, the issue of who would pay for repairs to the engine became fluid.

We reached out to Rolls-Royce for comment but received no reply—unacceptable. We were unable to find a copy of the Rolls-Royce warranty from 2007; however, the current warranty has calendar and engine-hour time limits for warranty coverage with the longest possible coverage time being four years. We think it's reasonable to assume that the 2007 warranty was similar.

The FAA looked at the engine. Its report is so highly redacted that its conclusion is unclear—although it did not issue an AD calling for inspection of engines built contemporaneously with Rosenlicht's.

Even presuming that the stone was missed during inspections when the engine was built and its presence was a manufacturing defect, it appears to us that Rolls-Royce would be within its rights and the law to deny a warranty claim because its written warranty put a time limit on its obligation to repair a manufacturing defect.

As is usually the case for insurance policies on turbine aircraft, Rosenlicht's policy covered damage from FOD. However, what is FOD? The stone was a foreign object that caused damage, but it is unlikely that it was sucked into the engine when it was on the aircraft. Rosenlicht's insurer, Alliance, declined to pay.

After extended discussions, Rolls-Royce paid to replace the gearbox and some other engine components.

Rosenlicht was left with a bill for $70,000 for the remainder of the work that was done to the engine plus the cost of removing and replacing it and transport to and from the engine shop. He also ate the cost of several months of downtime. He took out a loan to cover the cost. He is again flying the airplane.

Rosenlicht's plight is similar, on a larger scale, to what many aircraft owners have dealt with after a warranty expires—the gap between warranty and insurance coverage. Something goes badly wrong—for example, an inspection reveals that all six cylinders must be replaced. Insurance doesn't cover the situation—although it would have paid to replace the airplane if one of those cylinders came apart in flight and the airplane was torn up in the subsequent forced landing.

The owner may have been carefully setting aside money each hour for an engine overhaul, but the fund isn't big enough yet to cover the needed work. The owner is facing an expense that may require unloading the unrepaired airplane at a loss.

The gap between warranty and insurance coverage can mean facing crippling costs, especially on older aircraft.

We pass this story along with the caveat to prospective owners—an airplane and engine may require a substantial investment before each reach the end of their working lives. It's wise to plan accordingly.

Your airplane just came out of annual. If the shop made a mistake, will it fix it on its dime or are you going to get charged for the additional work? It depends.

maintenance performed. Part of the transaction you enter into when you buy a factory-new engine or GPS-comm or have an annual inspection done on your airplane involves buying a warranty on the work.

OWNER OBLIGATIONS

We strongly recommend that a prospective buyer read the warranty carefully to determine what is covered and what her or his obligations are. The big one is what the owner has to do to get work and parts paid for. Often, the work has to be done at a shop approved by the manufacturer—which can be expensive if no such shop is nearby or if the airplane has to be moved under a ferry permit. We've seen no warranties that pay the owner's cost of getting the airplane to and from an approved shop.

We have seen warranties that will pay for parts and labor at the owner's shop—most of those place limits on the number of hours of labor for various repairs. If your shop doesn't know your type of airplane well, you may be on the hook for the cost of its learning curve.

RECOMMENDATIONS

Our recommendations when it comes to warranties:

• Read the warranty before you buy an aircraft, component, have a refurb done or maintenance performed. If you don't like it, see if you can negotiate a different one—it's not often possible, but it's worth a try.

• If you don't like the warranty, go elsewhere for the product or service if you can.

• If something breaks during the warranty period, report it immediately and get in line to have it fixed under the warranty. If you wait until a day after the warranty expires, the seller can justifiably deny coverage.

• If something breaks during the warranty and you have it fixed under the warranty and then it breaks again, report it and demand that it be fixed under the warranty even if the warranty has expired. In our experience, repeated failure of a component with multiple attempts to fix it or replace it is an indication of a more serious problem. By being the squeaky wheel, we've seen manufacturers step up and continue to fix an ongoing problem involving the same component or system if the problem first manifested itself during the warranty period.

• Don't be a jerk. If your claim for warranty repairs is in the gray area of covered versus not covered, you increase your chances of coverage by stating your position professionally and clearly outlining what it is you want. Yelling and screaming at the person handling your claim is a good way to have the decision be "not covered."

CONSEQUENTIAL DAMAGE

When a component fails and damages other things, such as the engine or the airplane, the question of the extent of warranty coverage arises. If a connecting rod made out of improper materials fails during the warranty period, there is no question—the warranty will pay to replace the rod. However, if the con rod failure trashes the engine, will the warranty pay for repairs to the entire engine or is that something to be paid for by the owner's insurance? The answer lies in the terms of the warranty and the aircraft insurance policy. Trying to sort out the answer to events such as a defective con rod and engine destruction or defective side link in a landing gear that leads to a gear collapse and damage to an airframe and engine is the stuff that drives lawsuits.

In general, a warranty covers the cost of repairs to a component that is found to be defective. If the component causes further damage to the engine or airframe—not through wear, but due to a sudden stoppage, failure or collapse—the owner should look to the insurer to pay for repairs.

WHICH WARRANTY?

Unlike cars where the buyer deals with only the manufacturer for warranty repairs, airplanes are usually covered by a number of separate warranties—at the least, airframe, engine, propeller and avionics.

That means the buyer must learn the coverage of each and comply with the terms of each one to have repairs paid for under the warranty. That also means keeping track of expiration dates of each warranty. We don't like it, and we think it's foolish and unfair to someone shelling out the kind of bucks involved with a new airplane purchase—but it's a fact of life for many aircraft purchases and the owner must proceed accordingly.

CONCLUSION

We couldn't afford to buy airplanes or engines, or pay for maintenance, if manufacturers and repair shops were on the hook for repairs indefinitely—so we have limited warranties. That means considering the terms of the warranty as a part of the overall purchase.

Garmin's Wrist Pulse Ox: Reduced Accuracy

But with a heart rate monitor and other biometric functions, Garmin's D2 Delta PX aviator watch offers a generous feature set for pilots and athletes.

by Larry Anglisano

CHECKLIST

- (+) A pulse oximeter rounds out an already feature-rich user interface.
- (~) But if plain-vanilla pulse oximetry is all you want, there are plenty of lower-cost options.
- (~) Sampling SPO2 and heart rate on the wrist presents challenges, so expect degraded accuracy.

Compared to other portable gadgets, cockpit health monitors have been surprisingly slow to evolve. As an aging athlete, I obsess about heart rate, pulse and hydration, and add blood oxygen saturation to that list in the airplane.

Other athletic pilots agree that it sure would be convenient if there was one device that did it all, and since we covered pulse oximeters in the September 2017 issue of *Aviation Consumer*, Garmin released the D2 Delta PX aviator watch. It has an integrated pulse oximeter and a variety of other biometrics capabilities. I've been using it for close to a year and found that while it's not the perfect solution, it comes close, with limitations.

PREMIUM PRICED

When we last rounded up pulse oximeters we uncovered some favorites, which included high-end models like the Masimo MightySat and Nonin 9950, but still concluded that plain-vanilla entry-level monitors get the job done. Moreover, some later models of the Samsung Galaxy smartphones have a pulse oximeter function, and in general users report favorable results.

But combining pulse oximetry into the already rich user feature set of Garmin's latest aviator watch seems like a logical step up in utility. Having evaluated all of Garmin's earlier aviator watches, it's a feature I've always thought was missing, until now. But you'll have to dig deep into the wallet to get it.

The pulse oximeter is only available on the $1249 flagship D2 Delta PX watch and not the standard D2 Delta and Delta S models. The Delta PX also has heart rate monitoring, which is sourced via the sensor on the underside of the watch. The watch also connects with Garmin's chest heart rate sensors. More on this interface in a minute.

The Delta PX includes the SPO2 function as a widget and like other widgets in the feature set you access it with the lower left (Down) widget loop mode button on the watch face. The widget shows SPO2 as an elevation profile so you can monitor how the reading is changing relative to the altitude. There's also a color-coded awareness graph mode, displaying red, yellow and green (green is safe, red is not and yellow is marginal), along with a numeric readout of percentage of SPO2. There's also a graph summarizing samples from the last 24 hours.

WRIST-BASED LIMITATIONS

The first time you use the pulse oximeter widget the watch must have a valid GPS fix (it has a built-in GPS receiver) to determine elevation. During flight, the watch automatically takes pulse oximeter readings more frequently. The data is sent (via Garmin's Connext Bluetooth interface) to the biometrics data field on the Garmin Pilot smartphone app's dashboard.

Obviously, the watch samples SPO2 data at the wrist and several clinicians I talked with said that the fingertip (followed by the earlobe) offers the most accurate measurement of the saturation of oxygen in the blood. To review the basics, a

SPO2 on Garmin's D2 Delta PX, shown left, is displayed in both oxygen saturation percentage and as a color gauge.

typical finger-based pulse oximeter shines two beams of light through the finger—one beam is red and the other is invisible infrared. The two beams enable the instrument to detect the changes in color of the arterial blood caused by the heart pushing arterial blood into the finger. And there's the potential limitation of a wrist-based pulse oximeter.

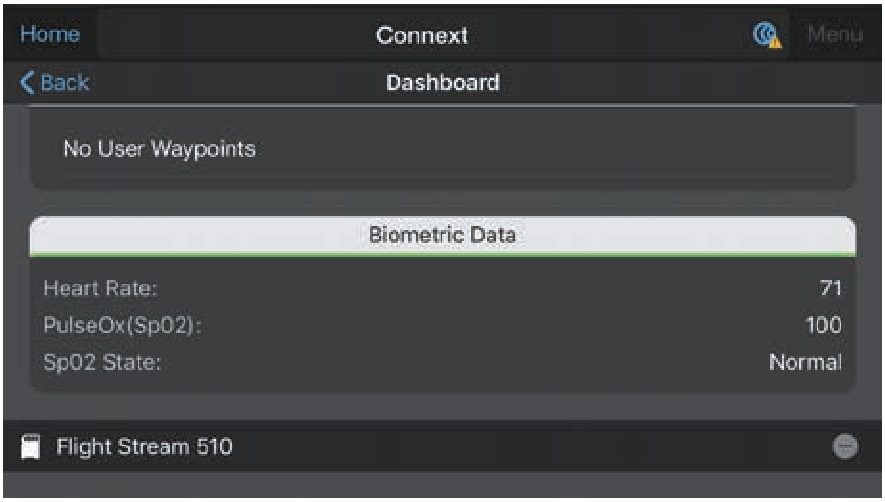
Since the change in arterial blood color is so small, a pulse oximeter works best when measuring in an area of a strong pulse signal, such as the fingertip. If the signal is too weak, readings might be skewed, or no reading may occur at all. This limitation was obvious when using the Delta PX's sensor. The manual warns that you must remain stationary for up to 30 seconds for the watch to obtain a sample and I found that challenging in flight. Even slight movements of the wrist were obviously hindering the device's ability to offer an immediate reading, or at least match the sampling speed of a traditional finger-based pulse oximeter.

As for accuracy, I compared the Delta PX to my Masimo MightySat pulse oximeter. Sometimes the two devices provided identical readings, and other times the spread was as much as 4 percent. Garmin offers caveats saying in part that its wearables aren't medical devices and the displayed data is not intended to be utilized for medical purposes.

Garmin's legal statement says that the Delta PX's pulse ox function simply provides an estimation of the user's SPO2 percentage. The fit of the watch on the wrist, the user's physical characteristics and the presence of ambient light may impact the device's readings. Garmin goes on to say that it may release device software over time to improve aspects of the measurements.

If you struggle with readings, the manual offers tips for erratic pulse oximeter data. This includes wearing the watch above the wrist bone—snug, but comfortable. You can also try holding the arm wearing the watch at heart level while it takes a sample. I use the watch with

YouTube See a video on the D2 Delta PX biometrics at http://tinyurl.com/j95ht2a.



The D2 Delta PX transmits biometric data—including SPO2 and heart rate—to the Garmin Pilot tablet app as shown in the screen grab at the top. The bottom image is the watch's pulse ox and heart rate sensors.

the silicon sport band (the PX comes with a leather band as standard) and the manual lists the sport band as something to try for better readings. You should also wash and dry the wrist (and the watch's optical sensor) before every use and ensure there isn't sunscreen or lotion on the skin below the sensor.

PLENTY OF FUNCTIONALITY FOR ATHLETES

At $1249, I don't think many pilots will be rushing out to buy the D2 Delta PX for its pulse oximeter function alone, but the feature nicely complements the device's aviation functions (we're covering the entire feature set in an upcoming comparison of cockpit wearables, including Apple's Watch).

But if you're an athlete and a pilot, the Delta PX offers sizable utility. During my trials, I used the Delta PX as an integral instrument for cycling training. This includes connecting the device to Garmin's chest-strap heart rate sensor and a new Edge cycling computer.

Like the pulse oximeter, the wrist-based heart rate sensor has limitations and I noted a typical spread of 5 BPM (beats per minute) when comparing the integral sensor with the chest strap. There's also a slight lag in displaying changes in HR.

But for pilot cardio patients who want to monitor pulse and heart rate as doctors I spoke with suggest they do, the D2 Delta PX gets it done.

Last, there are no FAA regulations that I can find governing the use of pulse oximeters, which makes the Delta PX fair game as a primary pulse ox as long as you absolutely understand and accept its limitations, just as Garmin suggests.

Engine Storage 101: The 30-Day Rule

Manufacturers suggest that engine inactivity in excess of 30 days might require the need for special preservation methods to fight corrosion.

Staff Report

Everyone knows that like vehicles, parking aircraft for long periods of time is just a bad idea, yet we see more otherwise good machines left in the weeds for months and even years. Shamefully, some don't even have cowl plugs installed. Someone will pay the price for these engines that simply sat too long, grossly unprotected.

How long is too long? It depends on the climate and how the engine was cared for during its time of rest. And as you would suspect, corrosion is the enemy. Herewith are some tips worth considering when parking the engine for long periods.

MOISTURE IS BAD

You don't have to be a combustion engineer to understand that corrosion in aircraft piston engines results from moisture being introduced into internal engine parts. In addition to ambient moisture, corrosion is also supported from the byproducts of combustion, which include moisture that contaminates the engine's lubricating system and helps to form acidic byproducts in the oil.

According to Lycoming, "Our experience has shown that in regions of high humidity, active corrosion can be found on cylinder walls of new engines inoperative for periods as brief as two days. In engines that have accumulated 50 hours or more time in service in a short period, the cylinder walls will have acquired a varnish that tends to protect them from corrosive action; such engines under favorable atmospheric conditions can remain inactive for several weeks without evidence of damage by corrosion." Lycoming goes on to reiterate that aircraft operated close to oceans, lakes, rivers and in humid regions have a greater need for engine preservation than engines operated in arid regions.

Conversely, for those engines subject to moderate amounts of blow-by and relatively high oil consumption, accumulating moisture and acid in the oil is a foregone conclusion, regardless of how often the aircraft flies.

In some respects, we can do only so much to keep the damaging impact of corrosion to a minimum, but some form of storage should be considered when limited operation and frequent periods of downtime are expected. Also, think in terms of shelf life because this would also be applicable to engines removed from the aircraft awaiting reinstallation at a later date. We know plenty of newly overhauled engines sit for long periods of time in unheated hangars.

The Continental Motors bulletin on engine storage is Service Information Letter 99-1, which has a specific checklist of products and procedures. There is also one published for fuel injection systems, SB 99-8B. For Lycoming engines the general publication is Service Letter L180B.

SHOULD YOU GROUND RUN?

Tempted to make tracks to the airport and fire up a slumbering engine for a few minutes of ground running? It won't get hot enough to do much good. It might do more damage than good. To quote Lycoming again: "Engine temperature and length of operating time are very important in controlling rust and corrosion. The desired flight time for air-cooled engines is at least one continuous hour at oil temperatures of 165 degrees F to 200 degrees F at intervals not to exceed 30 days, depending on location and storage conditions." That one hour of operation does not include taxi, takeoff and landing

The Lycoming IO-360 engine in the image to the left has a 2000-hour TBO, but don't expect to get there when parking it for long periods without care.

time. According to Lycoming, if recommended oil temperatures are not obtainable, contact the aircraft manufacturer for oil cooler winterization plates.

More than one tech told us that engines that are not operated in flight to normal operating temperatures at least once a week should be managed under some preservation or storage program to reduce the effects of corrosion.

In our view, the ground running of an engine is not a substitute for flying it when it comes to dispelling moisture. Running it on the ground simply doesn't get the engine hot enough, plus it tends to cause uneven heating at higher power, so you're likely just wasting fuel doing so.

Remember, all preservation/storage methods are concerned with one goal—keeping moisture and other corrosive agents from contacting metal surfaces by placing some type of protective coating or barrier between the metal and the corrosive-causing environmental conditions.

PULLING IT THROUGH

We spotted an interesting point in Lycoming's SL L180B on pulling the propeller through—something a lot of pilots do when the engine sits for a while. According to Lycoming, it's not recommended when the engine isn't run or flown for over a week or so.

"Pulling the engine through by hand prior to start or to minimize rust and corrosion does more harm than good. The cylinder walls, piston, rings, cam and cam follower only receive splash and vapor lubrication. When the prop is pulled through by hand, the rings wipe oil from cylinder walls," the bulletin says.

Additionally, Lycoming says the cam load created by the valve train wipes oil off the cam and followers. After two or three times of pulling the engine through by hand without engine starts, the cylinders, cam and followers are left without a proper oil film. Starting engines without proper lubrication can cause scuffing and scoring of parts resulting in excessive wear.

HOW MANY DAYS?

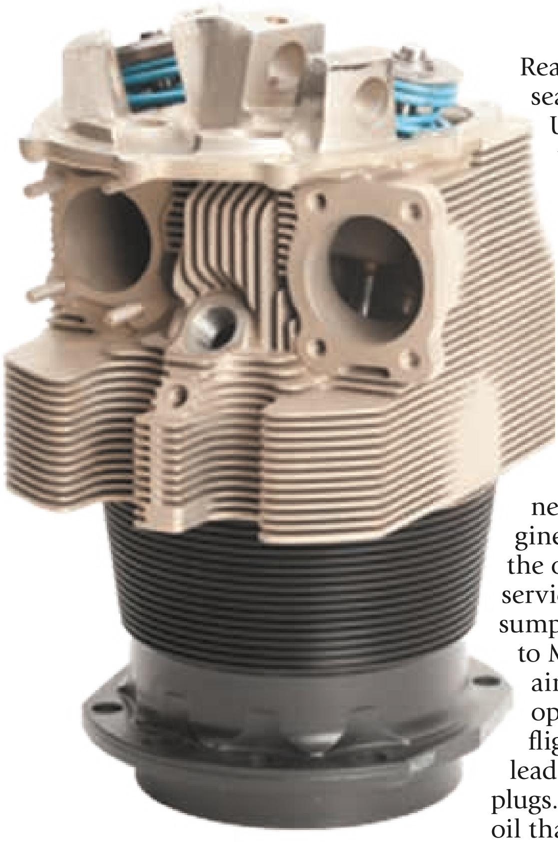
Both manufacturers agree that inactivity in excess of 30 days strongly suggests the need for some special preservation methods and chemicals, especially if the aircraft is located near saltwater or a similar humid environment.

Reader Scott Dyer sent us the top photo showing the real way to treat an engine that sits for even short periods of time. A cowl blanket and engine heat can pay back big. Digital engine monitors with an oil temp probe will prove that ground running won't heat the oil enough to do any good.

Lycoming offers a few procedures for installing a preservative, including draining the engine oil and replacing with a preservative oil mixture. It consists of one part by volume MIL-C-6529C Type I concentrated preservative compound added to three parts by volume of MIL-L-6082C (SAEJ1966), Grade 1100, mineral aircraft engine oil or oil conforming to MIL-C-6529C Type II.

Remove the top spark plugs and through the spark plug hole, spray the interior of each cylinder with approximately two ounces of the preservative oil mixture using an airless spray gun (one is the Spraying Systems Company Gunjet Model 24A-8395 or equivalent). In the event an airless spray gun is not available, a moisture trap may be installed in the air line of a conventional spray gun. Reinstall the spark plugs and don't turn the crankshaft after the cylinders have been sprayed. And remember, of course, the preservation mixture won't lubricate the engine, so don't run it.

If the aircraft is stored in a region of high humidity, or near a sea coast, it is better to use dehydrator plugs instead of merely replacing the spark plugs as prescribed. Cylinder dehydrator plugs, MS-27215-2 or equivalent, may be used.



Continental offers the NiC3 Nickel Silicon Carbide-coated cylinders, image above, for engines that fly less frequently or are based in maritime and humid climates.

Preferably before the engine has cooled, install small bags of desiccant in exhaust and intake ports and seal with moisture-impervious material and pressure-sensitive tape. Any other opening from the engine to the atmosphere, such as the breather, and any pad from which an accessory is removed should likewise be sealed.

Firmly attach red cloth streamers to any desiccant bags installed in the intake and exhaust passages to ensure material is removed when the engine is made ready to fly again. Streamers should be visible from outside the aircraft. The propeller should be tagged, "Engine preserved—do not turn the propeller." This isn't exactly a do-it-and-forget-it task.

At 15-day maximum intervals, a periodic check should be made of the cylinder dehydrator plugs and desiccant. When the color of the desiccant has turned from blue to pink the preservation procedure must be repeated.

Ready to fly again? Remove the seals, tape and desiccant bags. Use a solvent to remove the tape residue. Remove the spark plugs or dehydrator plugs. With the magnetos off, rotate the propeller by hand through sufficient rotation to remove excess preservative oil from the cylinders. Drain the remaining preservative from the engine through the sump.

To prepare the engine for long-term storage per Continental's SIL 99-1, drain the engine oil and remove and replace the oil filter with a new one and service the engine to the proper sump capacity with oil conforming to MIL-C-6529C Type II. Fly the aircraft for one hour at normal operating temperatures. After flight, remove all the ignition leads and remove the top spark plugs. Spray atomized preservative oil that meets MIL-P-46002, Grade 1, at room temperature through the upper spark plug hole of each cylinder with the piston at bottom dead center position. Rotate the crankshaft as opposite cylinders are sprayed. Stop the crankshaft with none of the pistons at top dead center. Re-spray each cylinder and install the top spark plugs, but not the leads. For long-term storage, Continental says to install dehydrator plugs in each of the upper plug holes, making sure each plug is blue in color. Use the same care in labeling the engine as described in the Lycoming section here. Continental recommends the cylinder bores of all engines prepared for indefinite storage must be re-sprayed with corrosion preventive mixture every 90 days.

OTHER PRECAUTIONS

Ideally, engine parts should be coated with some type of corrosion-prevention compound prior to storage, and all exposed surfaces, holes or orifices should be closed, plugged, or in some way protected from direct exposure to moisture. Propeller shafts should be treated with corrosion prevention treatment and wrapped with some type of barrier paper or moisture-resistant tape.

Fuel systems should be purged of all fuel and Continental claims that no special preservation preparation is necessary with Continental Motors fuel injection systems other than to completely drain the system. Recommendations for the Precision Bendix line of fuel injection servos is a little more complicated.

For servos subject to inactive periods beyond 28 days, the fuel servo and flow divider should be purged of all fuel and the fuel cavities flooded with 10-weight non-detergent oil.

The original equipment manufacturer for Marvel-Schebler carburetors recommends that the float bowl be drained and that a light coating of MIL-C-4339 preservative oil be sprayed in the throat of the carb and on any exterior surfaces. It does not recommend that the bowl interior be flooded with the oil.

Uninstalled fuel components should be preserved and placed in airtight bags with a small amount of wrapped silica gel. Pressure-injection carburetors should be drained of all fuel, the mixture placed in the full-rich position and grade #1010 (light lubricating mineral oil) introduced into the fuel inlet. When the preservative oil begins to flow from the uncapped vapor vent opening, all drain and vent plugs should be reinstalled and safety wired, and the inlet and outlet fittings capped for storage.

WAKE IT UP WITH CAUTION

It is important to remember that long-term preservation of engines can result in trapping large amounts of oil in the combustion chambers of one or more cylinders. For this reason, engines should not be rotated until all of the preservative oil is drained away. Failure to do so can result in damage to the piston, connecting rod and crankshaft of the flooded cylinder. If there is any question in preserving or waking up an engine, lobby the help of an A&P mechanic.

And it goes without saying that you need to service the oil sump with the correct grade oil and a fresh oil filter. Do a thorough ground run, followed by an engine leak check before flying it.

Last, be sure to log all of this effort. It will show prospective buyers how well you cared for the engine.

Traffic Tech Revisited: ADS-B Versus TAS

Selecting the right traffic system requires a thorough and accurate understanding of ADS-B and TAS target sourcing.

by John Merriman

The traffic system interface article in the January 2019 issue of *Aviation Consumer* deserves further clarification, particularly when it comes to comparing ADS-B and TAS (traffic alert systems). While the article's summary is essentially correct, readers may come away with a misunderstanding of how the ADS-B system works.

For example, the article referred to ADS-B ground stations as ADS-R stations, but they are not. The general term is Ground Based Transceiver (GBT). ADS-R is only one function of the GBT in which the GBT receives an ADS-B transmission on one data link frequency (978 or 1090 MHz) and rebroadcasts that transmission on the other frequency. This rebroadcast function only occurs if a client aircraft (ADS-B Out and In equipped) indicates in its transmission that it can receive only one frequency, and if the target aircraft is broadcasting ADS-B Out on the other frequency. Plus, both aircraft must be within a defined proximity (generally 15 NM horizontally and 3500 feet vertically) of each other.

It's easy to misuse the term TIS-B, giving the impression that this is the mechanism by which all traffic is derived in the ADS-B system. But TIS-B refers only to traffic information derived from FAA ground-based secondary surveillance radars for targets that are not ADS-B Out equipped, but are transponder equipped. These radar-identified targets are then broadcast via a GBT only if a client (ADS-B Out/In) aircraft is within 15 NM and 3500 feet of the transponder-only target. This data can have high latency (a minimum of four seconds up to 20 seconds) since it is derived from one or more ground radars and since track vectors must be computed from several successive radar scans.

To be clear, the primary mechanism for ADS-B traffic is the direct reception of ADS-B transmissions (from ADS-B Out equipped aircraft) by other aircraft that are ADS-B In equipped. These targets have very low latency and have almost immediate velocity vector information since this data is derived from the originating aircraft's GPS and included in the data stream. Consequently, ADS-R and TIS-B are only required is certain cases. ADS-R (via a GBT) is required only when a client aircraft has a single frequency receiver and cannot receive the frequency a target aircraft is transmitting, and TIS-B is required only when a target aircraft does not have ADS-B Out (but does have a transponder) and is in ground radar coverage.

A FEW WORDS ON TAS

It is true that TAS can show a transponder-only equipped target directly, whereas an ADS-B In equipped aircraft without TAS must see it with TIS-B, which only works in radar and GBT coverage. This is the primary advantage of TAS systems. A shortcoming of TAS, however, is that it does not compute course and speed (velocity vector) for targets; TAS only shows position. This limits the information available to pilots and limits the ability of TA (traffic alert) algorithms to accurately determine potential conflict. This is why adding ADS-B In to these systems can significantly enhance their performance, since ADS-B received directly is both more accurate than TAS-derived positions and contains velocity vector information. Note that current TAS systems that accept ADS-B input only receive on 1090 MHz and are therefore dependent on ADS-B rebroadcast (ADS-R) to obtain data from UAT-equipped aircraft.

The shift to ADS-B as the primary mode of surveillance in the U.S. airspace system means that many aircraft will ultimately be ADS-B Out equipped, and therefore ADS-B In equipped aircraft will have better performance than TAS in many situations. For instance, after Jan 1, 2020, in ADS-B airspace where all aircraft must be equipped, ADS-B direct traffic coverage will be complete. As the previous article correctly stated, the availability of velocity vector information on traffic displays (especially the relative vectors provided by Garmin) is an extremely valuable aid to anticipating potential traffic conflicts. This capability is available only with ADS-B, or with TAS systems integrated with ADS-B receivers. TAS will remain

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ForeFlight 11.0: 3D View, Breadcrumbs

ForeFlight's latest app update adds high-res aerial imagery of the airport environment and an advanced track logging utility.

by Larry Anglisano

Studying the static images of an unfamiliar airport environment may be a good way to know what to expect before you get there. But ForeFlight takes the concept a couple of steps further with the new Airport 3D View high-res terrain and aerial imaging utility in its popular Mobile tablet and smartphone app.

Available in the app's latest version 11 release, the new utility is standard in the Performance Plus and Business Performance subscription plans.

Version 11 also includes a new Breadcrumbs feature, which ForeFlight says can help in the training environment, particularly for helping master inflight maneuvers. Here's a look at the new utilities.

WORLDWIDE MODELING

ForeFlight's 3D View is an interactive streaming preview of airports across the world. In other words, if the airport is in the ForeFlight database, there's an associated photorealistic representation of the airport's layout and the surrounding terrain. The idea is to visualize what the takeoff, landing and approach will look like ahead of time.

The utility is partly the result of ForeFlight's partnership with Jeppesen, and the imagery uses Jeppesen-sourced high-resolution terrain covering every continent.

Think of the 3D View as a built-in camera, offering a near endless variety of vantage points that you can control by panning and zooming on the screen. You can pan and zoom 360 degrees around the airport and up to 15 miles away from it, while tilting the virtual camera from 3- to 89-degree viewing angles. This means you can eyeball the runway approach path or look nearly directly down on the airport.

The Glideslope Preview feature allows you to select a runway to get the view from short final because it automatically places the camera along the published glideslope. The real-world advantage here is obviously knowing what terrain and obstacles are in the way as you depart, land or go missed.

SIMPLE FEATURE SET

Airport 3D View is accessed by tapping a dedicated 3D View button on the airport's data page, or on the airport's pop-up on Maps. Overall, we think ForeFlight got the 3D feature right with an intuitive feature set. For example, there are selectable runway buttons in the upper right of the screen that allow you to visualize straight-in approaches by automatically positioning the camera 1 NM from the runway threshold along the published glideslope (or at an inclination of 6 degrees if no glideslope information is available).

Then you use a single finger to pan the view around and two fingers to pinch-zoom to extend the view out up to 15 nautical miles from the airport. A data readout in the upper left corner of the view

That's the ForeFlight 3D View of Lake Tahoe airport on an iPhone, and Portland-Troutdale airport on an iPad. The detail of the photorealistic airport environment is impressive and complete.

provides information about the runway and current camera elevation, and the distance and angle of the camera from the end of the selected runway. The program allows you to zoom in or out without rotating the camera to get a view of the runway at any point along the glideslope. Want to know what the environment looks like at the missed approach point? Zoom to it for a look-see.

In the top left of the view is a data readout that offers information on the camera's current position, including the altitude, distance from the pivot point and the inclination, in degrees. It also displays the airport's elevation. In the lower left of the screen there's a compass and basic map of the airfield.

When you select a runway, the utility automatically places the camera's pivot point at the end of the it, allowing you to rotate the camera around the pivot point. Tapping the runway button again returns the camera to the default position.

When airport METAR data is available, you'll see a windsock icon over the selected runway icon in the lower left.

The aerial imagery can be accessed in flight by using ForeFlight's Pack feature before takeoff because the program saves the departure and destination airport imagery in cached memory the first time you view it for a given airport. It also saves imagery for other airports along your route. Of course, you'll need an internet connection to initially cache the data.

TRACK LOGGING WITH BREADCRUMBS

The new Breadcrumbs feature in ForeFlight version 11 (it's included in all subscription plans) is an extension of the app's Track Log utility. In a nutshell, it allows you to see the aircraft's track log as it's being recorded. Breadcrumbs leaves a continuous onscreen line that you might reference for perfecting maneuvers, use for search and rescue efforts and even employ as an aid for aerial surveying work.

Since the Breadcrumbs feature can clutter the screen (especially on a smaller Apple smartphone) you can enable and disable it toward the bottom of the Map Settings menu.

The Breadcrumbs utility, which is part of the ForeFlight Track Log function, is shown on an Apple iPhone to the right. The Breadcrumbs logging is depicted by the green trail off the back of the airplane icon. That's an ADS-B traffic tag in yellow, showing direction and relative altitude in relation to the ownship.

But even if Breadcrumbs is turned off, it won't affect the app's track log recording function.

The app begins drawing the Breadcrumbs trail on the takeoff roll and stops drawing when you land, and the Breadcrumbs remain on the map display for up to 30 minutes after landing. The idea is to give you time to review them in a post-flight briefing with an instructor, as one example.

The Breadcrumbs trail itself is interactive because you can tap on it to see information about it. This includes the total recorded time, the distance traveled and also the average groundspeed.

If you want to clear the current Breadcrumbs track (useful if you're practicing multiple maneuvers), simply tap the Reset button on the bottom of the Breadcrumbs pop-up menu. When you do, the Breadcrumbs will begin redrawing from your current position on the map page. You can also tap the Save As Track Log button to not only remove the data from the screen, but to save it for reviewing it at a later time, and also to export the flight data. And even if you save smaller portions of the track log, the app will still capture the entire flight for review and export.

FOREFLIGHT'S CURRENT PRICING

A base subscription to ForeFlight starts with the $99 per-year Basic Plus package and includes VFR and IFR charting, app- and web-based flight planning, data-driven aeronautical maps, graphical briefings and aviation weather data.

The $199 per-year Pro Plus package adds georeferenced charts and synthetic vision, interactive icing and turbulence layers, ForeFlight's Plates on Maps feature plus Hazard Advisor.

Geared more toward jet ops, the $299 per-year Performance Plus package has detailed aircraft performance profiles, optimized auto-routing, pre-departure clearance and digital ATIS, fuel load planning, integrated JetFuelX pricing, trip assistance with fuel stop planning, plus FBO fuel orders and fuel releases.

For more on these subscriptions and to download a pilot's guide for the latest version 11 program, visit www.foreflight.com.

Cessna 310:

Sturdy and comfortable, Cessna's smallest twin makes for a good traveler. Recurrent training and commitment to maintenance are musts.

Cessna's first post-World War II twin-engine airplane, the venerable 310 is a logical consideration for anyone looking to step into the world of piston twins. While it doesn't come without some quirks, it's roomy, stable and has cruise speeds that top 200 MPH.

But before even considering any vintage of the 310 (it was produced between 1954 and 1981), any buyer needs to understand the airplane is complicated, particularly from a maintenance standpoint and even more so for one that hasn't been properly cared for. It can also be a demanding airplane to fly, especially for pilots who aren't properly trained.

Still, when maintenance and proficiency come together, a 310 could be among the most satisfying light twins to own. Better yet, our scan of the current market reveals a model line that has fairly strong resale value—especially for late-model airplanes.

Considering it's been in production for almost 40 years, and with many variants, it's no surprise 310 prices vary widely.

MODEL HISTORY

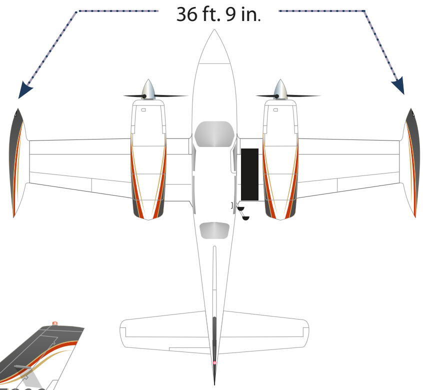
Cessna introduced the 310 in 1954, finding a niche between Piper's original, relatively underpowered PA-23 Apache, introduced a year earlier, and Beech's Twin Bonanza, which went out of production a few years later. It competed most directly against the Aero Commander 520, but that model was discontinued the same year. The 310 was Cessna's first all-metal, modern twin—replacing the prewar T-50/AT-17 "Bamboo Bomber"—and was clearly focused on business transportation. It foreshadowed the company's subsequent products and helped usher in its future growth. And its featured presence in the 1950/60s television drama "Sky King" didn't hurt anything. Its namesake hero, played by Kirby Grant, upgraded to a 310B shortly after that model became available. Named "Songbird," the airplane (several were actually used during the show's production) was as much a star of the series as its actors, perhaps becoming the main reason for the show's popularity on Saturday mornings throughout the 1960s.

Cessna's aggressive pursuit of the business market manifested itself in not only the 310's looks, but also its refinement: Many production years saw a new model designation. Cessna brought out the 310B in 1958, the 310C in 1959 and the 310D in 1960, eventually getting to the 310R in 1975 (with a few gaps) before ending production in 1981.

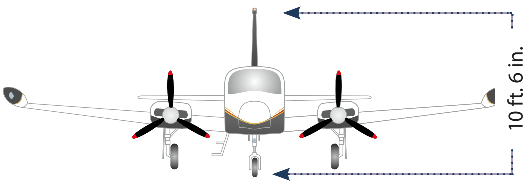
The first 310s came with 240-HP Continental O-470-B engines. From the beginning, a sleek, powerful appearance was a design goal, with tight cowlings

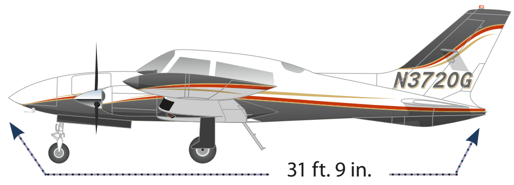
It's tough to argue that the Cessna 310 has timeless good looks after all these years. Inflight handling is sturdy and stable, making it a good IFR platform.

CESSNA 310R



Drawings courtesy www.schemedesigners.com

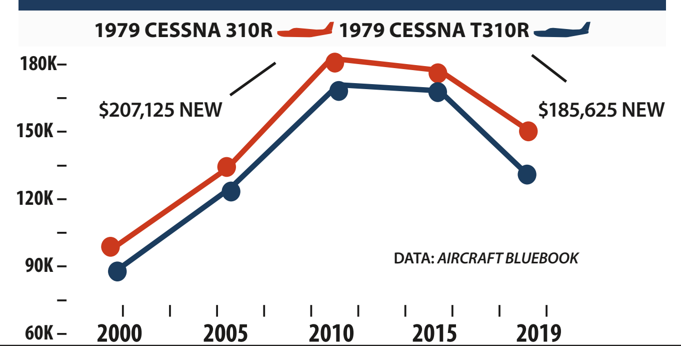




CESSNA 310 MODEL HISTORY

MODEL YEAR	ENGINE	TBO	OVERHAUL	FUEL	USEFUL LOAD	CRUISE	TYPICAL RETAIL
1954-1958 CESSNA 310, A,B	CONT O-470-B,M 240 HP	1500	$25,000	100	1750 LBS	178 KTS	±$30,000
1959-1961 CESSNA 310 C,F	CONT IO-470-D 260 HP	1500	$30,000	100/132	1751 LBS	191 KTS	±$36,000
1962-1963 CESSNA 310 G,H	CONT O-470-D 260 HP	1500	$30,000	100/132	2037 LBS	191 KTS	±$46,000
1964-1965 CESSNA 310 I,J	CONT IO-470-U 260 HP	1500	$30,000	100/132	2037 LBS	194 KTS	±$50,500
1966-1967 CESSNA 310 K,L	CONT IO-470-V 260 HP	1500	$30,000	100/142	1975 LBS	193 KTS	±$58,000
1968 CESSNA 310 N	CONT IO-470-V 260 HP	1500	$30,000	100/183	2075 LBS	193 KTS	±$61,000
1969 CESSNA 310 P	CONT IO-470-V 260 HP	1500	$30,000	100/183	2030 LBS	193 KTS	±$74,000
1969 CESSNA T-310 P	CONT TSIO-520-B 285 HP	1400	$35,000	102/183	2108 LBS	225 KTS	±$87,000
1970-1974 CESSNA 310 Q	CONT O-470-VO 260 HP	1500	$30,000	100/203	2086 LBS	192 KTS	±$95,000
1970-1974 CESSNA T-310 Q	CONT TSIO-520-B 285 HP	1400	$35,000	100/183	2108 LBS	225 KTS	±$98,000
1975-1981 CESSNA 310 R	CONT IO-520-M 285 HP	1700	$30,000	102/203	2047 LBS	194 KTS	±$128,000
1975-1981 CESSNA T-310 R	CONT TSIO-520-B 285 HP	1400	$35,000	102/203	1777 LBS	223 KTS	±$135,000

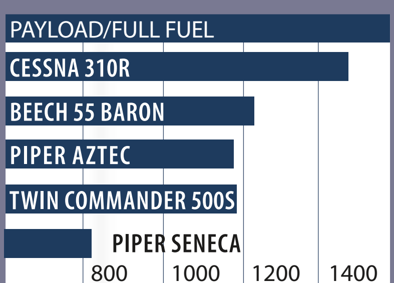
RESALE VALUES

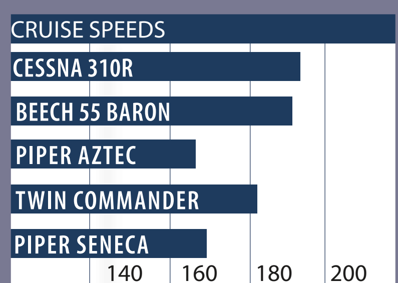


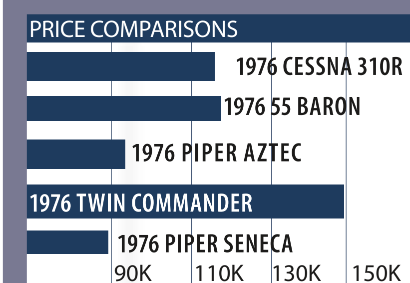
SELECT ADs

AD 90-02-13	MAIN GEAR STRUT BEARINGS
AD 76-08-02	TIP TANK/STROBE LIGHT
AD 73-07-07	FUEL LINE, WIRING CHAFING
AD 72-03-07	LANDING GEAR UPPER STRUTS
AD 69-15-09	MINIMUM FUEL PLACARD

SELECT MODEL COMPARISONS







The guys at Ohio-based Aircraft Sales Inc. refurbished this 310R, top, to near-new condition as part of the company's Pristine Airplane resale program. Late-model 310s have plenty of instrument panel space for avionics upgrades.

and streamlining at the nose and tip tanks (at least by the standards of the day). Split wing flaps eliminated the need for external brackets or tracks and their drag.

Distinguishing features of the early models are multiple aft side windows, a straight tail and non-canted "tuna tanks," named for their shape. When the 310B came out in 1958, it brought with it a 100-pound boost in gross weight.

For the next year's 310C, an engine change and gross weight bump occurred with the fuel-injected, 260-HP Continental IO-470D. The TBO was 1500 hours, same as with the earlier powerplants.

For the 1960 310D, Cessna swept the tail, as it did across its fleet.

The next significant change was in 1962, with the 310G. Cessna introduced canted "Stabila-Tip" tanks, said to be more aerodynamically efficient than the old design. The original non-canted and bladder-equipped tip tanks also had a fuel pickup problem; an airworthiness directive mandated a hefty increase in unusable fuel. This 310, with bladderless all-metal canted tanks, swept fin and short nose, is often said to be one of the most attractive light twins ever built.

Cessna didn't stop there. Cabin size was increased, along with gross weight. What started as a five-place twin became a six-placer with 1963's 310H. By next year's 310I, wing lockers and auxiliary tanks became options, as did three-bladed props. One significant difference was the switch from the corrosion-prone overwing exhaust design to an improved underwing arrangement on the 310I. An engine change accompanied the modifications, to the IO-470-U, still of 260 HP and still with a 1500-hour TBO. Another engine change, to the IO-470-V, occurred in 1966 (310K), along with extended, one-piece aft windows on each fuselage side.

In 1969, Cessna consolidated its model line, offering a turbocharged variant of the 310 alongside the normally aspirated 310P. The T310P came with 285-HP Continental TSIO-520-B engines (1400-hour TBO), three-blade props and a 5400-pound gross weight, compared to the normally aspirated 310P's 260-HP IO-470V Continentals, optional three-blade props and 5200-pound gross.

From 1970-74, Cessna stuck with the 310Q and T310Q, despite bumping gross weight on the 1972 T310Q to 5500 pounds (5300 for the non-turbo version) and changing to wrap-around "Omnivision" windows by adding a pair of small panes at the top of the aft cabin.

In 1975, the 310R II and T310R II sported one of the biggest changes since the type's tail was swept: an extended nose. The proboscis grew 32 inches, housing a sizable baggage compartment. The normally aspirated version also got 285-HP Continental IO-520-M engines (1700-hour TBO) and another 200 pounds were added to the gross weight—bringing it to 5500 for both the turbo and non-turbo versions—along with improved landing gear.

The 310R marked the airplane's final configuration, which continued until the line was closed down in 1981. All told, some 5700 copies of the 310 were manufactured, not including its various military versions. Unsurprisingly, the 310Rs are the most numerous, followed closely by the 310Q, a result of sticking with one model for several years.

PERFORMANCE, HANDLING

An old saying about piston twins—they have two engines because they need two engines—refers to what's necessary to obtain their performance and their handling when one engine fails. Both are strong points of the 310, especially the turbocharged versions. Early models feature high-speed cruise in the neighborhood of 175 knots while later ones will top out at around 190.

The turbo'd models can present 225 knots at all-out max cruise, but the fuel burn will be breathtaking. Reduced power settings get 175 knots on later, non-turbocharged models.

Engine-out performance is better than average, with normally aspirated 310s achieving a single-engine service ceiling of just under 7000 feet to 7500 feet, depending on model. Turbos see single-engine service ceilings of 17,000-18,000 feet and climb rates from around 330 to 440 FPM, depending on model and turbocharging.

Figure cruise fuel between 20 GPH for an early, non-turbocharged 310 at economy settings up to 35 or more when flogging a big-bore turbo. Join the Church of the Lean-of-Peak and shave that down to around 28 GPH. Airspeed suffers, of course. Double those numbers, at least at the low end, for takeoff and initial climb.

Speaking of climb, the non-turbocharged models do fine in the low teens and turbo models in the high teens, although their service ceilings can be as high as 28,200 feet (T310Q). They're happiest in the mid-to-high teens: One owner told us, "At FL250 (the T310R) performs like a very expensive Skylane."

Book short-field performance is surprisingly good, especially for the airplane's weight: Landing over a 50-foot obstacle in a 310R will consume 1790 feet, compared to a Model 58 Baron's 2498. Taking off over that same obstacle will require 1700 feet in the 310, while a Baron needs 2100 feet. As you'd expect, pilots and owners treat the book numbers with a grain of salt, reporting poorer real-world numbers.

Once airborne, however, 310s provide an extremely stable platform. The only fly in the ointment is the type's tendency to Dutch roll, especially in turbulence and in an inexperienced pilot's hands, caused in part by the high rotational inertia of fuel in the tip tanks. Experienced owners tell us Dutch rolls are easily dampened with proper technique.

Visibility is good out the front and side windows, top, while the rear cabin isn't cavernous, but ample for average-sized adults.

As clean and powerful as the 310 appears, it can get draggy on approach. Relatively large props blank out much of the wing and split flaps produce much more drag than lift. This can be a "good thing," since the clean airframe can be difficult to slow down until the first notch of flaps is deployed.

Early models came with an approach-flap extension speed of 140 knots, with full deployment available at 120. The 310K bumped the approach-flap speed to 155 knots or so. Subsequent models through early 310Rs are placarded for 160 knots approach-flap extension and 140 knots for full flaps. Drop two knots from those numbers for late 310Rs.

CABIN LOADING

For the early models, up through the 310G, interior space is about average for baggage, which means having to stow some items under and between seats, or at passengers' knees. Beginning with the stretched cabin of the 1963 310H, more baggage space was opened up. Wing lockers, whether installed at the factory beginning with the 310I or in the field, can help, as does the 310R's nose baggage compartment. Removing the aft row from the six-seat airplanes (quick disconnect seats were optional on later models) can help, too.

Weight and balance must be watched closely. The first nose extension—a small one—occurred with the 310K. But by the 310I, cubic feet available began to exceed the airplane's weight-lifting capability. No longer could a pilot "cube-out" a 310

CESSNA 310 MISHAPS: GEAR COLLAPSE

On the 65th anniversary of the delivery of the first Cessna 310, we sought to find what a review of the 100 most recent accidents would reveal about this enduring marque.

With a fuel system frequently described as complex or challenging, we were especially interested in the fuel-related accident numbers. We found only eight—about half what we've observed for twins with "simpler" fuel systems such as the Beech Baron and Cessna 337. Of the eight, one was caused by fuel contamination that affected only one engine, one pilot positioned a fuel selector valve between the "main" and "aux" positions and the remainder either mismanaged the fuel aboard or didn't bother carrying enough.

We can't help but wonder if having a fuel system that requires some initial study doesn't cause pilots to approach fuel management more carefully than in other twins.

We were concerned about the high number of gear collapse accidents—23. There were also two events in which the pilot was unable to extend the gear because of a mechanical failure. That's a lot. We think that it's because of a loss of institutional memory about the demands of rigging the 310 gear. It's not hard, it just has to be done right—by the book. There are no shortcuts.

Would-be 310 owners need to fully understand that it generally takes two techs, who know what they are doing, some eight hours to rig that electromechanical gear. They have to start in the middle of the airplane and work progressively outward toward all three gear legs—and they have to do it per Cessna's manual, adjusting tensions and getting rid of parts that are out of tolerance. Plus, you cannot rig just one gear leg—it's a recipe for a gear collapse or jam.

Pilots should also be aware that if the nosegear strut is bottomed-out, it's a no-go item. On retraction, the nosegear will jam in the well and will not extend.

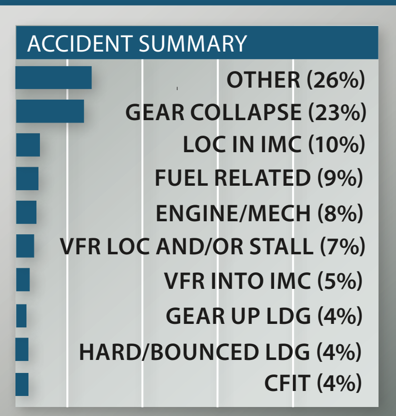
In our opinion, the 310 gear works well, but it does not tolerate a casual attitude toward maintenance nor any shortcuts.

We saw that there were no injuries in any of the landing gear-related accidents, although we did see one seriously stupid pilot trick. Our hero faced an emergency: The gear would not extend. He decided to intentionally create another emergency, one we doubt he'd practiced for—a double engine failure. He shut down and feathered both engines—and crashed short of the runway. Doh.

We were impressed that there were only two runway loss of control (RLOC) accidents—and one of those was on an icy runway. With its wide-track gear, the 310 has excellent ground handling.

Sadly, we saw how important it is to be most cautious on a first flight out of maintenance. One pilot's preflight didn't catch that the elevators had been rigged backward. He crashed fatally, shortly after takeoff.

Following major work on one engine, one pilot decided to ferry his 310 to another airport gear down because the needed repairs to the gear hadn't been completed. You got it, the engine work was done improperly and it blew out all of its oil. Even with the prop feathered, a 310 won't hold altitude on one engine with the gear down.



before overgrossing it and it could be loaded out of forward CG. Adding lots of avionics and other options to the typical model only compounds the problem by upping the empty weight. One solution is STC'd vortex generators that can boost max gross by 100 pounds or more. That said, you can find late-model 310s with close to 2000 pounds of useful load.

The 310's full-fuel payload varies depending upon the model, equipment and fuel tank arrangement. Total usable fuel capacity can be 100, 132, 142, 183 or 203 gallons—from 600 to 1218 pounds of fuel. Full-fuel payload in a lightly equipped 310C with auxiliary tanks might exceed 700 pounds, while it could be as low as 400 pounds in a 310R. Other loading and operating considerations, like maximum landing weight and zero fuel weight, were introduced with later models.

FUEL SYSTEM

The 310's fuel system on airplanes with all the optional tanks is more complicated than most. It also has a number of idiosyncrasies. The complications start with nomenclature. Ask a line person where the main tanks are on a given airplane, and they'll likely point to the wing. With the 310, they'd be wrong. Early models only came with the 50-gallon-per-side tip tanks. As there were no tanks in the wings at all, those were main tanks. As time went on, horsepower increased and so did demands for fuel. First came 20-gallon wing-mounted bladders, followed by an additional 11.5-gallon bladder, for 31.5 gallons in each wing. Then came 20-gallon tanks in the wing lockers. In a 310R, as much as 203 gallons can be available.

If the pilot has the mains topped and takes off without checking the fuel actually went into the right spot you can guess what might come next. That's not the only tricky thing about the 310's fuel system. A fully equipped 310 with wing locker tanks can have up to 10 fuel drain points and eight fuel pumps. Connecting all this is a relatively complex (when compared to other piston twins) plumbing system. There's no separate gauge for each tank, though the gauge does switch automatically to read the tank being used (but not the wing locker tanks, which have no

That's a RAM-converted T310R, top photo, and John Rolls' R-model proving the airplane has plenty of handsome ramp appeal, bottom.

fuel level senders). The pilot can read the tanks not in use by toggling a switch. Confused yet?

Fuel feeds to the engines from either the mains or the aux tanks (but not from the wing locker tanks, if installed). Presuming the mains were full at takeoff, at least an hour's fuel has to be burned off if the airplane has 20-gallon aux tanks (90 minutes for 30-gallon aux tanks) because excess fuel is pumped back to the mains. If there isn't room for it in the mains, it goes overboard.

The mains also are the receptacle for the contents of the wing locker tanks and there has to be room for transferred fuel. The pilot should wait until there's 180 pounds or less in the mains before pumping from the locker tanks. The aux tanks feed directly to their respective engine, and the only pump serving them is engine-driven. In the event that pump or engine fails, the aux tank on that side could hold 30 gallons of dead weight; there's no crossfeed from the aux tanks to the opposite engine. Hopefully you'll never discover this factoid the hard way, but those big tip tanks were originally designed as a safety feature, to get fuel as far from the cabin as possible.

Early on, a prototype landed gear-up and the tip tanks separated just as they were designed to do, with no post-crash fire.

The good news? The 310 is not unduly prone to fuel mismanagement accidents, so despite the system's apparent complexity, pilots seem to have little trouble dealing with it. All those tanks can carry a great deal of fuel, making six- or seven-hour endurance possible in later models. Early models go for four to five.

LANDING GEAR

The other 310 system usually getting lots of attention is the landing gear. It's relatively tall and, as a result, often thought to be more delicate than with other airplanes. Also, all that fuel hanging out on the wingtips tends to create high side loads.

As with so many other general aviation landing-gear systems, one of the keys is finding a technician familiar with and knowledgeable about it. The 310's gear system includes a number of components requiring proper rigging during regular inspections. Done properly, trouble can be avoided, but failure to treat the gear with respect increases the odds of failure dramatically.

People with keen familiarity with the 310 tell us of three weak points in the gear system. The nosegear idler bellcrank, located under the pilot's feet, is probably the worst since its failure—always at retraction, and always loudly—means two prop and two engine teardowns.

The main-gear torque tubes and inner landing-gear door actuator bellcrank are the other two. If the torque tube fails, it does so during the retraction sequence, leaving the associated main gear down and locked. Extend the rest of the gear and land. If the inner landing gear door actuator bellcrank fails, the inner gear door hangs in the breeze.

Later-model 310s have heavier main gear torque tubes and side brace support brackets. Cessna has a kit available to retrofit earlier airplanes.

Another gear issue that deserves mention is the brakes. Early models had problematic Goodyears. Many were retrofitted with the later, and better, Clevelands. Still, the 310 is large and heavy enough that brake performance can be marginal. Nail the speeds on landing.

MAINTENANCE

A scan of FAA Service Difficulty Reports going back several years dredged up numerous entries, underscoring the 310 fleet's age. Items garnering our attention included a cracked rear mount bulkhead in a right main (tip) fuel tank, sheared

Later models like Rick Ferrin's C310R, top, are easy to spot because of the longer nose. The short-snouted one at the bottom is a 1956 A-model.

horizontal stabilizer attach bolts and a brake disc cracked where its manufacturer's name was stamped. But the single system receiving the most entries was, by far, the landing gear.

This in itself reinforces the need for a 310 expert to conduct any prepurchase inspection and for a shop with intimate familiarity to do your ongoing maintenance. That said, most retractable-gear airplanes originally designed in the 1950s likely will require similar attention and expertise.

MARKET PRICES

When considering an airplane in production for almost 30 years, and with so many variants, it shouldn't come as a surprise 310 prices vary widely. An early "straight" 310 averages only $30,000 or so in today's market, rising to $148,000 for a 1981 turbocharged T310R, per the winter 2019 *Aircraft Bluebook*. Between those extremes, there's no real "spike." Instead, each successive model sees a modest increment in price. The biggest single gap is between the 310Q and 310R—the 1974 310Q averages around $100,000, while the 1975 310R has a typical retail price around $110,000, according to the Bluebook. The gap for the turbo models is similar. With those "starting" prices, there's no question the 310 can be a good bargain. On the other hand, keep in mind that ones with low-time engines, modern avionics and nice paint and interior work sell for a lot more. We spotted an air conditioning-equipped 1978 310R on the market for $219,000.

MODS, TYPE CLUBS

Modifications for the various 310 models run the gamut, from the usual avionics upgrades to improved cabin heaters, auxiliary fuel tanks in the nacelles and cabin, and electrically de-iced props. Other mods include vortex generators (VGs), something we highly recommend for all twins when available. They often come with gross-weight increases, as they can reduce critical speeds. Check Micro AeroDynamics at www.microaero.com, 800-677-2370.

PowerPac Spoilers (www.powerpacspoilers.com, 800-544-0169), as their name implies, offers a spoiler kit for the 310R; it requires the Micro AeroDynamics VG kit.

Colemill STC engine and prop upgrades are available from Mike Jones Aircraft (www.mikejonesaircraft.com, 615-896-5678) for the 310F through R, and may come with gross-weight increases. A choice of IO-520s or IO-550s is offered; prices and performance gains depend on aircraft model and options selected.

Also, RAM Aircraft (www.ramaircraft.com, 254-752- 8381) offers engine upgrades for the 310R, but mainly focuses on upgrading powerplants for the turbocharged 310 models.

All piston-powered twin Cessnas have their own support organization in the form of The Twin Cessna Flyer (www.twincessna.org, 877-977-3246), and the group is a valuable source of knowledge for all things related to Cessna twins.

OWNER COMMENTS

I spent nine months looking at Cessna 310s as they are one of the few aircraft that actually meet my needs (and are in my price range). I flew a 310R back in the late 1970s for my first flying job, and I remembered what a wonderful-flying airplane it was.

I purchased a 1977 310R last April and have put close to 100 hours on it so far. I am absolutely thrilled with the airplane as it does everything it was designed for both economically and efficiently. I operate off of a 3000-foot private grass strip and the vortex generators make a huge difference. In fact, I would never want to fly another twin without VGs.

I flight plan for 190 knots, burning 27 GPH rich of peak. With the addition of GAMIs and a new engine monitor in the near future, I will certainly run LOP, as I have a fair amount of experience doing that in my other aircraft.

As an A&P/IA, my direct operating cost is probably somewhat skewed. But The Twin Cessna Flyers's association claims an average of around $347 per hour. I would say mine is closer to half of that. And my insurance rates are what I would consider to be rock bottom at $2350 per year, with full hull value set at $100,000. I do have a fair amount of seasoning (airline flying), so that plays into it. I would certainly give Epic Insurance Solutions (www.epicinsurancesolutions.com) a try. I found them to be wonderful and they also provide the coverage for my other aircraft.

Likely the area of the aircraft that most people have an issue with is the landing gear rigging. But if you have it rigged properly—strictly per the maintenance manual—it's not a problem. It's actually a very stout gear.

I would say to anyone interested in a 310 that they should join The Twin Cessna Flyers. The information that I have received, both in locating an aircraft, as well as operating and maintaining it, has been invaluable. I would also talk with the folks at TAS, arguably the premier Twin Cessna maintenance facility in the country. They're located in Defiance, Ohio, and they have been extraordinarily helpful.

Rick Ferrin
via email

Since 1981, I've owned four 310s, two of them being the R model owned in the 1980s, one of them being a 1957 model owned in the 1990s, and the 1956 model I own now, N5267A. I also helped manage and flew a 310R from 2000 to 2009 for two non-pilot business partners.

I admit I am partial to the straight-tail classics. Why the 310? With the R model, my wife and I, along with our two 200-pound sons and 200 pounds of luggage and scuba gear, flew nonstop to a dive location over 500 miles away in just over three hours and still had 1.5 hours of fuel left for full cruise power.

My 1956 model can easily handle four full-sized adults, each with a typical airline-legal carry-on suitcase, and go 400-plus NM with IFR reserves. With just me and my wife, we can take all the gear we want, plus fill the auxiliary tanks and easily add another 200 NM to that nonstop range.

My R models typically trued out in the 180- to 190-knot range, with chock-to-chock fuel burn rates of around 25 GPH. My 1956 model regularly trues out at 170 to 173 knots while showing a block fuel consumption of 21 GPH. Any 310 is a rock-solid flying machine, great on instruments and a nice short-field performer, especially with VGs.

The biggest mistake first-time legacy twin buyers make is thinking that just because these planes can be bought for nearly a song, that they will be equally cheap to operate. Parts and labor will be as much, if not occasionally more, as a $1.3 million new Baron.

You must also build your support network of mechanics who truly know the airframe. And as with most other legacy GA aircraft in today's market, what you invest in it now won't be what you realize on resale. But when you consider that for under $100,000, you can have a showpiece 310 that will run with new birds costing seven to ten times as much to buy, that resale depreciation point is moot.

If you go into 310 ownership with the mindset that you are spending this money on the airframe and upgrades because it's what you want now, rather than worrying about the next owner and resale, then you will be rewarded with many years and flying hours of what I think is one of the best and most plentiful twins general aviation ever offered.

Guy R. Maher
Cleveland, North Carolina

I bought a mid-time Cessna 310R a few years ago as my first twin-engine airplane and it has been a love-hate relationship. I love the performance because I can pretty much count on 185 knots without it even breathing hard, and that's with both engines pulled back enough (LOP) to not eat my lunch on the fuel burn.

It's also an incredibly comfortable traveler. I normally load the right seat with my wife and one rear seat with our teenage son. I remove one of the aft seats to better accommodate bags and other stuff we travel with.

As for the hate part, the maintenance is intensive compared to my Saratoga. Cylinders, landing gear issues, exhaust, autopilot—you name it. Buyers need to understand this going in. It's a complex but very capable twin. You'll pay to play.

Larry Cherenski
via email

The Aviation Consumer

Instrument Repairs

(continued from page 12)

we've seen a resurgence in aircraft owners deciding to keep their legacy instruments rather than upgrading to full-up EFIS because of the other expenses that tag along with aircraft ownership," Copeland said. That could make sense. But in our view, if a vacuum DG fails, the $1000 or so it takes to get it overhauled is far easier to swallow than $10,000.

"An Aspen glass upgrade isn't in my immediate future because I dropped $60,000 on a new engine," one airport neighbor recently told us. He decided to have his failed attitude gyro and aging DG overhauled instead of making the switch to a more reliable solid-state display and ditching the vacuum system in favor of going all electric.

For certain, the instrument repair and overhaul business isn't going away any time soon. Copeland points out that there are hundreds of thousands of aircraft in the field still equipped with legacy instruments and they simply need to be supported.

On the other hand, the support network for doing so has certainly shrunk over the past few years. A lot of smaller instrument shops have gone out of business, leaving fewer options for getting legacy instruments repaired. Even some manufacturers are scaling back their support network. BendixKing curtailed its dealer network and only sells service parts to four facilities around the country.

Our advice is this: If you have a legacy instrument that needs to repaired, it's time to do some math. First, ask your shop where it plans to source the replacement (or repair), ask if it's a full teardown overhaul and what is the length and terms of the warranty. Then, get a couple of proposals for an EFIS replacement, weighing the benefits of going with all-electric, solid-state technology. For some the benefits will be compelling, for others, not so much.

ADS-B Tech

(continued from page 21)

a valuable addition to ADS-B if you feel you need traffic information in areas below radar or GBT coverage in situations where target aircraft are transponder equipped, but not ADS-B Out equipped. This combination of factors might occur outside of rule airspace, close to the ground in hilly terrain or in remote areas. Even so, TAS can only detect transponder-equipped aircraft.

A combination of the two systems would certainly give the best coverage, although as time goes on this advantage might grow less compelling and considering cost, the value of this approach would have to be carefully evaluated, in our view.

A NOTE ON EQUIPMENT

Many aircraft are equipped with older TAS systems and when adding ADS-B In/Out to them, it is certainly an excellent idea to integrate them with a system such as the Garmin GTX345 and L-3 Lynx NGT9000 (to name two) as shops report many buyers are doing. This provides an even better solution than just a newer TAS with added ADS-B since dual-band ADS-B receivers will merge data from ADS-B and TAS sources and give the best solution.

Two worthy sources for study include the FAA's Advisory Circular 90-114A (Mar 2016), and the Surveillance and Broadcast Services Description document, SRT-047 Rev. 02, Nov 2013 (FAA Surveillance and Broadcast Services Program Office).

FEEDBACK WANTED

PIPER J3 CUB

It's time again to take a fresh look at the Piper J3 Cub market in an upcoming Used Aircraft Guide in *Aviation Consumer*. We want to know what it's like to own these classics, how much they cost to operate, maintain and insure and what they're like to fly. If you'd like your Cub to appear in the magazine, send us any photographs (**full-size**, **high-resolution please**) you'd like to share to the email below. We welcome information on mods, operating expenses or any other comments that can be helpful for buyers considering one. Send correspondence by May 10, 2019, to:

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