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The Aviation Consumer

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CAMGUARD'S NEW EXTENDED-LIFE OIL

How long is too long for oil change intervals? Ed Kollin, the creator of the oil additive CamGuard and an early researcher for the Exxon Elite oil blend, believes too many operators are stretching oil changes beyond the capabilities of even the best aviation oil. If you only fly between 25 and 100 hours per year, you could be in that camp. As a result, ASL CamGuard has been flight testing a new oil that might safely double oil change intervals. First, some background.

I dusted off several aircraft operating manuals on the bookshelf and found that some manufacturers suggest changing dispersant engine oil at 100 hours. Forget that—those manuals were written in the Reagan era. Aircraft engine manufacturers have since standardized the oil change interval to 50 hours on engines with spin-on oil filters and 25 hours on engines with filter screens. According to Kollin, he has done enough engine wear analysis to suggest there is zero scientific basis in these recommendations, with plenty of trashed cams, rings, spawled lifters and other toasted engine components as evidence. Where's the smoking gun? There are several.

Think beyond oil filter technology because even the most modern filters simply can't filter out water, acid and blow-by gasses. Blow-by is a smorgasbord of raw and partially burned aviation fuel, carbon dioxide and tiny lead particles that sneak past ring seals, eventually forming damaging sludge and deposits in the engine. Consider that the majority of wear on the surface of lifters and cams comes from abrasive particles (ingested dirt, sand and silicon dioxide, for example) in the 10-micron range—far smaller than the 60-micron filtering capabilities of a paper oil filter.

As for oil longevity, the key is dumping it before it can no longer suspend the oxidized blow-by fuel that, according to Kollin, "causes virtually all oil-related problems" we're seeing with typical air-cooled aircraft engines. Kollin stresses that preventing the deposit-forming liquid fuel component and other contaminants in fuel blow-by is just as important as preventing corrosion. Ten-hour oil, he says, is already corrosive due to water contaminated with salts and acids, and is partly the basis behind the corrosion- and sludge-inhibiting CamGuard oil additive product, which has been shown to repel water and acidic molecules by filming on the surface of engine metals at shutdown.

In trying to determine how often you need to pull the drain plug, Kollin developed an algorithm that considers a slew of factors, including rich of peak and lean of peak engine operation, the size and horsepower of the engine, climate characteristics, normal cruise oil temperature and other operational variables. When he hit the Go button, he came up with oil change intervals from 25 to 35 hours—the period in which the dispersant in the typical aviation oil is used up, and when the damage begins.

Tentatively named Advantage, the new 25W50 oil (25W60 for radial engines) would contain the right amount of additives to safely extend oil change intervals to 45-50 hours. Without revealing his secret sauce, Kollin said that Advantage will of course consist partly of the CamGuard additive. "The goal is to have the Advantage (at 50 hours) chemically look like a Phillips/CamGuard mixture does now at 25 hours," he told me. Kollin was realistic in admitting he's not sure if the oil can make 50 hours, but field testing—which is currently underway—will tell. He also admitted the oil would cost a bit more, but I think the delta could be made up in longer change intervals. We'll keep tabs on Advantage's development and look at oil additives in an upcoming issue of *Aviation Consumer*.

Speaking of keeping tabs on things, you can now follow *Aviation Consumer* on its new Facebook page, http://tinyurl.com/zkky79x. In between issues, we'll post pertinent news stories, commentary and also present our product review videos linked from our new YouTube channel. Check it out.—*Larry Anglisano*

BATTERY TECH

I read with interest Jim Cavanaugh's article on battery upkeep and battery minders in the September 2016 issue of *Aviation Consumer*. I am a big believer and have had great results (including eight years of reliable service) from two Concorde gel mat batteries set up in series in a 24-volt Beechcraft Sierra. My question to you relates to testing.

I had been told that using a 12-volt load tester on each battery is the approved method to test for battery condition. I was also told to fully charge the battery and then let it sit for a day or so before testing it with a load tester. This was not mentioned in your article and I am wondering if this is not a better test. As the article suggested, should I use hydrometer testing instead?

Paul Werbin
via email

Concorde's Don Grunke told us the battery should be fully charged and let sit for at least 12 hours to stabilize the internal temperature. As for testing, Concorde suggests using a hydrometer that's at the same temperature as the battery. For-hire flying requires a capacity test (not a load test) to determine that the battery is capable of maintaining 80 percent of its capacity.

Worth mentioning is parasitic load—a small, continuous flow of current—that takes power from a sitting battery, even when the aircraft's master switch is off. Some clocks and onboard computers can draw enough amperage to kill a battery that sits for even a short time. This repetitive low-current drain causes the battery plates to sulfate and deeply discharges the battery more than normal operating loads.

Parasitic drain is measured with a calibrated, ammeter-equipped multimeter. Concorde offers a parasitic load test adapter (PLTA) for batteries with an MS3509 quick disconnect receptacle.

Your battery maintenance article in the September 2016 issue should be a huge resource for owners like me who struggled with nagging battery problems.

As your article warned, problems in the charging system can lead to the expensive shotgunning of batteries. I know this too well. My shop wasn't properly equipped to test the charging system in my Cessna 177RG and I went through three batteries in a span of four years.

I ended up at another shop that diagnosed the problem to a faulty voltage regulator. The old regulator was barely flowing 12.5 volts at most power settings. A new alternator and regulator, plus an accurate adjustment, brought the charging system voltage right where the battery needs it to be.

Nick Cabrella
via email

GARMIN G5 EFI

Would you explain the difference between Garmin's non-STC'd experimental-category G5 electronic flight instrument and the new G5 that was just released with an AML-STC for certified aircraft?

Tim Boese
via email

The main difference is the G5 with AML-STC (approved model list supplemental type certificate) is intended to be used entirely as a standalone instrument. This means, unlike the version made for experimental applications, it won't work with Garmin's autopilot and it can't be interfaced with an external GPS and navigational source.

The other difference is price. The STC'd version is $2495, while the non-STC'd is $1350, with optional battery.

FAA FACE SLAP

I have comments to add to editor Larry Anglisano's commentary in the August 2016 issue of *Aviation Consumer* where he wrote about the FAA's $500 ADS-B equipage rebate.

The agency's $500 rebate is a slap in the face for every law-abiding proactive citizen who has already equipped his or her aircraft for the ADS-B mandate. First, we pay higher prices due to less competition and then we have to deal with the additional hassles of performing updates while the system gets ready for prime time. That's all fine—it was our choice to equip early.

But, the $500 handout is not the FAA's money. It is money that we—as taxpayers—pay to the government. So now, in addition to the activities to get the ADS-B system going, the proactive have to pay additional money to the procrastinators. No wonder the political climate is changing for the worse.

Gerd Pfeifle
Vero Beach, Florida

CORRECTION

In the Battery Upkeep article in the September 2016 issue, we incorrectly stated the name of battery tender cable manufacturer Enhanced Flight as Advanced Flight. Enhanced Flight/Audio Authority can be reached at 859-233-4599.

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AVIONICS MARKET SCAN

Buying Used Avionics: Plan For Refurb Work

Installing used avionics and instruments could make sense for some, but consider testing fees, flat-rate repairs and installation hardware when shopping.

by Larry Anglisano

If you thought even a modest new avionics upgrade was in the budget, but proposals are proving otherwise, plan B might be buying used equipment. While this isn't a bad plan, a hasty buying decision might end up costing more in the long run. This is especially true when buying complex instruments and avionics that require factory service. Worse is buying equipment, having it installed and paying for trouble-shooting when it doesn't work.

In this article, we'll take a look at the current used avionics market, the potential costs of pricey factory service and some common traps to avoid at any cost. We can't cover all equipment, but we'll look at some that may cause problems.

CHASING THE PAPERWORK

The first step is to differentiate marketing lingo from FAA airworthiness matters. And it does matter, because installing shops—especially FAA repair stations—will need supporting paperwork when it's time to sign off the installation—whether they generate the paperwork in-house or acquire it from another shop.

One marketing term that's stuck around for years is the so-called yellow tag, a sticker that might be placed on the component representing it as being in serviceable condition. In the eyes of the FAA (and the technician endorsing the aircraft logbooks), a yellow tag affixed to the component means nothing unless it references a completed FAA form 8130-3. This is the form the technician or repair station representative completes and signs after a part has been tested, inspected (and perhaps repaired) and found to conform with manufacturer specifications. You might find 8130-3 forms attached to the logbook or placed in the flight manual.

Depending on its operating specification (aka ops specs) most manufacturers will provide an 8130-3 after reconditioning or remanufacturing a component to original specifications. Depending on its repair station procedures, some shops will assign a green tag to a component, which generally means the unit is expected to be serviceable or repairable, but it hasn't been through the evaluation process yet. A red tag likely means the component is beyond reasonable repair or perhaps was cannibalized for parts, rendering it unfit for installation. If you source used avionics from an end user, it might not have any airworthiness documentation at all. Consider these avionics to be "as removed" and in unknown condition. Be ready to pay for bench time, which according to our research can be as little as $90 to as much as $150 or more per hour.

It's tough to say what, if any, warranty will come with used equipment. We found that equipment bearing fresh 8130-3 paperwork typically has a 90-day warranty. Reputable shops may warranty an overhauled component for as long as one year. You should get the specific terms in writing. This is especially important for more complex systems and those with high-price replacement parts, including weather radar, systems with CRT displays and complex gyroscopic instruments.

Kevin Helvey at Wentworth Aircraft in Crystal, Minnesota, told us missing paperwork isn't a deal-breaker for the used equipment it sells, but that it could cost you more. "The majority of installers will end up testing the equipment before installing it anyway, so they can issue tags," he told us. True, but that's billable.

Connecticut-based Bennett Avionics, top, has a full inventory of used navcomms.

CHECKLIST

- There are plenty of reputable sellers of quality used gear.
- Sacrificing warranty coverage for a minimal price break seldom makes sense.
- One flat-rate factory repair could eat any price savings and actually cost you more.

Since Wentworth isn't an FAA Repair Station, it doesn't have the ability to issue an 8130-3. Instead, it places a 30-day warranty on used equipment it sells and (for an extra fee) can coordinate bench testing and certification through its network of shops.

Worth mentioning is the STC and installation requirement for the S-TEC line of autopilots—which Wentworth generally keeps in inventory. Helvey and shops we talked with stressed the importance of purchasing (through parent company Genesys Flight Systems) an applicable STC kit to support the installation at an approved Genesys dealer. Even if you have all of the correct autopilot components for a given aircraft (these systems are airframe-specific and have operating voltages, bracketry, wiring and other hardware that varies among airframe types) you could spend an additional $1500 or more on the STC paperwork package, which includes wiring schematics, blueprints, install documentation and other paperwork that comes with the system when sold new.

A STRONG MARKET

We see a strong secondary market for used equipment, likely due to the high costs of new gear. According to a recent report by the Aircraft Electronics Association, retrofit avionics amounted to 46 percent of sales during the first six months of 2016, or more than $509 million. The rest came from forward-fit OEM sales, which was more than $1.1 billion.

To combat the slump, avionics shops are making used sales a larger part of their business. You'll often find them selling on eBay, Barnstormers.com, in an online store and traveling to trade shows with used equipment to pedal.

Dave Fetherston, a principal at Nexair Avionics in Massachusetts, recognizes enough market demand to launch an online store for the variety of avionics his shop takes in trade. Fetherston offered several caveats.

"Buyers need to be aware that used radios must have traceability, and sometimes eBay sellers have broken equipment removed from their airplane," he told us. He wasn't the only one that stressed the importance of buying from a reputable shop that has a return policy.

What about sourcing your own equipment and carrying it into a shop for them to install? You might pay more for the labor—or be turned away. We've heard of shops slapping a premium on the installation of used equipment it didn't provide. That makes sense because shops rely on the profit margin they make on new equipment sales.

It may look more modern than your current panel, top, but this stuff is long out of production. Installing a used autopilot like an S-TEC 30, middle, requires airframe-specific components and a $1500 STC package. Without a solid warranty, vintage instruments like the NSD360A HSI, bottom, are risky buys.

"Good shops are busy right now and it's understandable why some might instead choose a customer for new equipment over a direct labor job on someone's used radio," Fetherston acknowledged.

Like every other shop we spoke with, Nexair Avionics certainly will work with customers and their used equipment, but with guidelines. It's made clear that the equipment must include complete installation kits. Lopped-off interface connectors don't cut it.

OBSOLETE PARTS

Every established seller we spoke with reported sizable demand for replacement navcomm equipment.

SELECT FACTORY REPAIR COSTS			
MODEL	FLAT-RATE COST	TYPICAL USED PRICE	COMMENTS
Garmin GNS530W	$1100	$9000	Installation kits no longer available.
Garmin CNX80/ GNS480	$1100	$6500	Some, but limited ADS-B compatibility.
Garmin GTX327	$575	$1000	This is Garmin's mode A/C retrofit transponder.
L-3 WX500 Stormscope	$1535	$3000	Antenna replacement is additional.
BendixKing KX155/165	$1750	$2500	Includes display replacement and cosmetic refurbishment, but not unrelated repairs.
Garmin GI106A	$600	$1000	This is the navigational indicator that's often paired with a GNS/GTN navigator.
Garmin GDL88 ADS-B	$950	Depends on model	Some mandate-compliant ADS-B equipment is appearing on the used market.
BendixKing KI525A HSI	$2500	$500-$1500	Core serial number should be greater than 10,000 or have mods 5 through 10.
Century NSD360A HSI	$3500	$1100-$2000	Example is overhaul or overhauled exchange through Mid-Continent Instruments and Avionics.
Aspen EFD1000Pro	$2395	$9500	Display requires factory evaluation to support installation approval, per the AML-STC.
Garmin aera796 portable GPS	$700	$1100	Price includes the latest software revision.
Avidyne EX600 MFD	$2150	$2000-$2500	Testing and certification is priced at $750 if the unit has current service mods and doesn't need repair.

This includes the popular BendixKing KX155 digital radio. However, the extinction of the gas discharge display—a common failure component—makes buying this otherwise reliable radio a risky proposition.

Consider that the KX155/165 radios came to the market in the early 1980s—making some of them today over 30 years old. If by chance the radio has an original display, you could eventually eat a repair invoice that approaches $1700. That's because the old gas discharge display has been replaced with a new LCD, requiring a field (or factory) mod for it to work. BendixKing recently created a factory refurbishment program (through a service bulletin) for the front end of KX155(A) and KX165(A) radios, which will carry a one-year warranty. The $1750 factory refurbishment includes a replacement bezel, lenses, knobs and of course the LCD display. Field replacement (less the bezel and knobs) could run $1300.

Just when we gave up on Narco support—particularly gas discharge display replacements for the venerable MK12D digital navcomm—we learned through several shops that a vendor is producing replacement displays. That may extend the useful life of the fleet of existing MK12D and other later digital Narco equipment. While support still exists, we don't think buying them makes sense.

Aircraft and Avionics Sales in New Cumberland, Pennsylvania, specializes in Narco repairs. Company principal Paul Haubert told us his shop receives nearly a dozen Narco radios for repair each week. He quoted us $275, plus bench labor, to swap a failed MK12D display with a new one. Haubert also told us his shop has been performing all kinds of repairs on Narco equipment and sourcing parts isn't a real problem. They can be reached at www.aircraftandavionics.com.

But servicing other equipment like the UPS-AT GX-series navigators might be a problem. The display vendor for this system is gone. That could leave you scrambling to buy another unit to use for parts before you even have it installed. Who needs that hassle?

INSTRUMENTS, GLASS

You'll find all sorts of flight instruments on the used market. This includes mechanical slaved HSIs, basic iron gyros, first-gen retrofit EFIS and even later-generation OEM and retrofit glass, including the popular Aspen Evolution PFD. There's even Avidyne Entegra and Garmin G1000 components—most removed from wrecked aircraft. Pay close attention to factory repair pricing on any of these. If the equipment is out of a salvaged aircraft, you could be stuck with stuff that can't even be installed and signed off.

Avidyne's Tom Harper stated company policy that says any Avidyne equipment that was installed in an aircraft involved in an accident (as described in 49 CFR 830.2) shall not be serviced or recertified. If the aircraft was involved in an incident, the equipment may be repaired or certified, but only after a review of the situation and circumstances of the specific incident. Avidyne charges a flat-rate testing and recertification fee of $1300 for an Entegra PFD. Flat-rate repair pricing is $7800 and can depend on mod status. Avidyne's testing/certification fee is $750 for the EX600 MFD, a TAS traffic processor and the DFC90 autopilot, but only if no mods or service are needed.

Avidyne has a sizable rotable pool to support its installed base of Entegra and retrofit avionics, but doesn't sell factory overhauled equipment.

Installing a used Aspen PFD or MFD system requires the display to first be evaluated by the factory so the installing dealer can use the AML-STC. Aspen's Michael Studley, director of field service engineering, recommended that the RSM (remote sensor module) be replaced due to

The L-3 Skywatch display has a CRT (cathode ray tube) that costs $4576 to replace. L-3 will bench test it for $625.

Clockwise from upper left: Don't buy a used BendixKing KX155/165(A) without evaluating the display. A replacement starts at $1300. The good news is that support for venerable Narco equipment like the MK12D navcomm is still available, but understand you are buying an orphan. Some shops insist on installing new antennas with used WAAS navigators. The ones that came with the system may be weathered and aging.

the susceptibility of damage to the magnetometer during removal. The RSM is $440 for exchange, while servicing the display is on a case-by-case basis.

With a market flooded with aging HSI systems, it's tempting to make a steal-of-a-deal on a BendixKing KCS55A HSI/slaved compass system, as one example. There are several critical and complex components in this system, including the KG102A remote gyro. These live hard service lives—not made any healthier by sitting in a box in a hangar or the closet. Before committing to this system or any gyro instrument, we strongly suggest having it bench tested by a shop that's familiar with it.

Understand the true disposition of an instrument's recent service history, and the difference between ones that are represented as being rebuilt and overhauled. There is a difference and it's easy for uneducated sellers to falsely represent the instrument's status. For instance, 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 either conform to new part tolerances and limits. Bryan Miner at Mid-Continent Instruments and Avionics in Kansas told us it doesn't represent instruments as being rebuilt, despite tearing them all the way down, cleaning everything inside and replacing components needing replacing.

You can learn a lot about the status of an instrument by reading a shop teardown report, which you should ask for. A gyro overhaul generally includes replacing the bearings and any worn mechanical parts. It also includes disassembling the rotor assembly, while replacing any worn parts in it. It should also include calibrating the electronic outputs, if the instrument drives an autopilot. In many cases, you'll have to pay extra to have the shop align the newly overhauled gyro with the autopilot flight computer it interfaces with. These are fine adjustments that command proper autopilot bank angles, roll rates and flight director command bar presentation. This is one of many reasons why it's important to get an accurate proposal to install used equipment before the job starts, and after the shop has all of the required parts on hand. The last surprise you want is having to shell out additional money halfway through the job because you (and the shop) didn't plan on additional accessories and parts.

For basic instruments like airspeed indicators and plain-vanilla directional gyros, some shops might perform basic repairs on a case-by-case basis. Again, read the teardown report for an idea of what was repaired. If done right, you could save money on a repair versus overhaul. As an example, Mid-Continent Instruments and Avionics quoted us $2400 as the average list price for repairing a Century NSD360A HSI, and $3548 to overhaul it. The warranty for the repair is 90 days on the specific parts that were replaced. It's one year for a complete zero-time overhaul.

Last, you could buy something that's not serviceable at all, even when buying a core unit with a plan of having it overhauled. Such deal-breakers include components with missing data/identification tags, those found to have excessive corrosion and early-production products with extinct replacement parts.

IS THE SAVINGS ENOUGH?

In our view, only in rare occasions does it make sense to source the latest avionics from the used market. Reader Randall Dean's experience proved that patience could pay off.

"I held out for most of the items I wanted to show up on eBay and was able to purchase a nearly new Garmin GTN750 with 23 months of warranty remaining, along with the Aspen MFD1000, a Garmin XM system, a WX500 Stormscope and even an S-TEC 55X autopilot," he told us, admitting he spent north of $40,000,

ADVICE FROM A LEGACY AVIONICS SPECIALIST

In the early days of avionics retrofitting, guys like Harley Bennett were (affectionately, he says) called junkies. Now they're referred to as legacy avionics specialists. Bennett fell into a nearly 50-year career buying and selling used avionics after equipping his flying club airplanes for IFR using more affordable used avionics. It was the used avionics listings in the publication *Trade-A-Plane*, plus a demand from avionics shops, that made him realize he could make a living in a business that does nothing but sell used avionics. Bennett has no interest in competing with avionics shops, so his company doesn't sell new avionics and it doesn't do installations.

"To our knowledge, we are the only established avionics company who deals only with used equipment. It's this narrow focus that allows us to offer what we believe is the best service at affordable prices," he said. Bennett was an early member of the Aircraft Electronics Association (AEA) and says his company has worked hard to create and foster a solid working relationship with traditional avionics shops around the world. That means if he doesn't have an item a buyer is looking for, he knows where to source it. The company stocks and ships a wide variety of equipment—from navcomms to weather radars—from its East Granby, Connecticut, warehouse.

Selling only certified equipment with a 90-day warranty (or with a one-year warranty for an additional 10 percent), Bennett Avionics subcontracts all repair and certification work to a network of shops around the country and utilizes experienced techs who are open to working on older avionics. In our estimation, that's one challenge in buying used equipment. The bench techs who were once skilled in repairing old equipment have been replaced with new talent who aren't versed in older analog designs.

Bennett makes a reasonable case for buying used equipment. "For clients trying to decide on new or used avionics, I advise them to first establish a budget and consider how important it is to recover the investment when they sell the aircraft. They'll likely recoup a larger percentage of the investment in used avionics because it took a hit in depreciation on someone else's watch," he told us. On the other hand, he acknowledges that used equipment isn't for everyone.

Bennett said you should insist that any used equipment you buy is first tested, certified and comes with the appropriate installation hardware. Also, consider recommendations from fellow aircraft owners. "The avionics industry is a small one and the reputation of a seller (including shops) is enduring," he said. Speaking of enduring, Bennett cautions against investing in stuff that's just too old, or also too much. "After all, how many 40-year-old television sets are you watching in your home? Plus, when making a buying decision, think about the avionics you need for the mission, versus the ones you want," he advised. In our view, that's solid advice that applies to both used and new avionics. Contact www.bennettavionics.com.

but still saved thousands. With the help of his shop, John Revere priced a used GTN750 and some other avionics for his Bonanza, but recognized only a $1200 savings overall. "The full-term factory warranty for the new equipment just made better sense," he admitted. John Dendecker, the general manager at Carpenter Avionics in Smyrna, Tennessee, advises his customers to consider the warranty when making the decision.

"My rule of thumb is that the savings for used avionics has to be at least 20 percent less than new equipment to even think about sourcing current-production used avionics," he told us.

Dendecker pointed out that the majority of factory-new equipment has a two-year warranty, sometimes longer. As the pricing chart on page 6 shows, out-of-warranty repairs for newer avionics can cost as much as you might pay for the equipment.

When it comes to installing used autopilot systems, Dendecker and other professionals suggested the cost savings should be at least 50 percent of a new system. Part of that has to do with sourcing hardware that might be missing from the supplied kit. This includes things like trim command and disconnect switches, servo mounting brackets, bridal cables, wiring harnesses and the previously mentioned STC and paperwork kit for S-TEC autopilots.

While the caveat applies to all used equipment, it's even more important to make absolutely certain that autopilot components are fully functional before the job commences. And just because a component is functional doesn't mean it's up to the current mod status and software revision. These costs (not to mention freight charges to send equipment out for evaluation) add up in a hurry.

"If I'm installing a used system and find that it doesn't work, I could be spending considerable amounts of time troubleshooting because I'll assume the problem is related to the installation, only to conclude there is a problem with one or more of the components. The customer pays for this time," Dendecker cautioned.

CAVEAT EMPTOR

If you think used avionics make sense for your situation, our advice is to work closely with your shop when it comes to sourcing it— if they even agree to install it. They'll spot red flags easier than you might.

Ask the seller to agree to returning your money (or make good on the repair) if a bench test reveals problems. Shy of buying new stuff from the start, that's one more layer of protection in a deal that could cost more than you thought it would.

Portable CO Detectors: CO Experts Best

For protection against aviation's silent killer, we recommend a portable CO detector. We liked all the ones we surveyed, with CO Experts' unit on top.

by Rick Durden

We'll say it up front—in the great scheme of things, your risk of getting hurt or killed in an aircraft accident due to carbon monoxide poisoning is on the low end of the spectrum. From what we can tell, it's a little below that of having a midair collision. Nevertheless, it's not zero, our airplanes are aging and maintenance isn't perfect, so if you fly in an area where you use your heater during at least half the year, we think it's wise to have a detector in the airplane that will alert you to even very low levels of CO.

CO in the cockpit usually arrives through the heater ducting due to a crack in the muffler. Cracks don't heal themselves. Worse, they can get dramatically larger on short notice and deliver a massive quantity of toxic, odorless, colorless gas. Being able to detect low levels of CO means being able to fix a problem before it becomes severe.

In our experience, a portable CO detector that reads out low levels of CO is the right tool for the job. It's not as expensive as a panel mount, often more capable and it can be used to sniff around the cabin for localized CO concentrations. We found a problem in the baggage area of a Cessna 150 some years ago with a portable CO detector. Exhaust gases were entering the rear fuselage and flowing forward into the cabin past a poorly sealing baggage curtain.

We surveyed the most popular portable CO detectors that we consider suitable for general aviation use as well as the old-familiar chemical spot detectors. Bottom line: We consider all of the electronic units to be satisfactory—but like the CO Experts Model 2016 for its sensitivity, followed by the Tocsin unit. We're not crazy about the chemical spot devices due to lack of low-level information—although they will change color when exposed to high levels of CO if you replace them when the makers say to do so.

We spot checked the electronic portables and spot units by placing them in a plastic bag and exposing them to a CO source. All worked as advertised. Here are the units we surveyed, in no particular order.

Our top three portable units: Tocsin OI-315 CO Cockpit Monitor, left; Pocket CO 300, middle; and CO Experts Model 2016, right.

TOCSIN

Offered by Sporty's (www.sportys.com), the $169.95 Tocsin OI-315 CO Cockpit Monitor by Otis Instruments Inc. is a CO detector that can be mounted almost anywhere in an aircraft. It has a belt clip, mounting ring and hook and loop tape so it can be clipped to a map pocket, hung from a knob or hook or attached more permanently as desired. It features a real-time CO concentration level readout on an LED screen starting at 1 PPM and running through 500 PPM—a more than adequate range, in our opinion.

The Tocsin first alarms at 35 PPM with a flashing LED light, a 90 dB Piezo horn and the unit vibrates. There is no time delay between the unit sensing a 35 PPM concentration and the alarm—a good feature, in our opinion. In our opinion, 35 PPM is the maximum level for a first alarm. The Tocsin's first alarm can be silenced. If CO concentration continues to increase, the Tocsin's high-level alarm activates immediately on sensing a 100-PPM level. The high-level alarm cannot be silenced except by moving the unit to a fresh air location and shutting it off. We think that can be a significant distraction.

The alarm levels can be customized by the user, although the manufacturer cautions against doing so. The unit also has time and date features and a data logger. The Tocsin is rated for temperatures from -20 degrees C to 50 degrees C.

We were not impressed with the manual that came with the unit. It was not easy to understand and a number of important terms were not defined—the writers seemed to

SELECT CO DETECTORS COMPARED				
MODEL	PRICE	TYPE	ALARMS	COMMENTS
Tocsin OI-315 CO Cockpit Monitor	$169.95	Portable electronic	35 and 100 PPM	Real-time CO readout on LED screen; two-year useful life but can be refurbed for $85.
CO Experts Model 2016	$199.00	Portable electronic	7, 10, 25, 35 PPM and "High"	Real-time CO readout; will display alarm memory, exposure history and oxygen displacement; five-year life
Pocket CO 300	$132.75	Portable electronic	50, 125 and 400 PPM	Keychain unit; real-time CO readout; tracks total exposure, eight-hour average exposure and max exposure
GasAlertClip 24 and 36 Month	$159.95 $272.95	Portable electronic	35 and 200 PPM	Real-time CO readout; data logger; exposure data can be downloaded; 24 or 36 month useful life
Aero 452-101	$499.00	Panel mount electronic	50 and 90 PPM	No readout of CO level; green light if CO is below 50 PPM gives false sense of security
Aero 551	$599.00	Panel mount electronic	75 (after 5 minutes) and 300 PPM (within 1 minute)	Real-time CO readout above 9 PPM; fits standard 2.25-inch instrument cutout; low-level alarm trigger level is too high and should not have a time delay, in our opinion
Aero 553	$699.00	Panel mount electronic	50-70 (after 5 minutes) and 300 PPM (after 1 minute)	Real-time CO readout above 29 PPM; 5-7 year life; features include clock functions; low-level alarm trigger is too high and should not have a time delay, in our opinion
Chemical Spot Detectors	$4.50-$9.95	Stick-on spot that changes color	None	Useful life ranges from 90 days to 18 months and must be replaced; no low-level CO indication; better than nothing; only Quantum Eye has color-coding for interpreting spot

assume that a user would understand the jargon. The sensor is rated for two years. Otis Instruments recommends returning the unit to its service department after two years for sensor element and battery replacement, calibration and complete unit inspection. The cost is $85.

CO EXPERTS

CO Experts has been making what we consider to be the most sophisticated low-level CO detectors for years, and it's been making them progressively smaller with more features. Originally designed for household use, the company eventually recognized the value of low-level detection in aircraft and added some features of value to pilots. With an 85 dB Piezo alarm, there is no concern about missing a warning even if the unit's not in sight. We've used various models over the years and found that they were sensitive enough that we got an alarm one time while waiting to depart from AirVenture in a twin because the ambient wind was blowing exhaust from the left engine into the cockpit through the pilot's vent window.

Available through Aeromedix. (www.aeromedix.com) for $199, the newest in the CO Experts line is the Model 2016. It displays CO starting at 1 PPM and makes its first alert immediately at 7 PPM. It has a graduated series of alarms as the CO concentration rises—there is no time delay between hitting a concentration level and the alarm sounding. It has a silence feature allowing the user to shut off the alarm temporarily—the length of time the alarm will remain silent decreases at higher CO concentration levels and the alarm will sound again after silencing if the CO level increases.

The Model 2016 also has an alarm memory and recall functions to display exposure history as well as the approximate percentage of oxygen that would have displaced by CO in the body of someone who experienced that exposure. We feel that is valuable for an inflight exposure event, especially as it will help determine if there is a need for treatment and provides valuable information for medical personnel.

The unit has an expected life of five years and includes a failsafe monitoring system that warns of a detector failure, low battery and impending end of life of the unit.

POCKET CO

We like the idea of a CO detector that we routinely carry with us—maybe on

Chemical spot detectors from Sporty's, left; Quantum Eye, bottom; and ASA, right, have definite limitations but don't deserve the bad rap they've received. GasAlertClip 36 Month, top, is an industrial-grade unit that is thrown away at the end of its useful life.

a keychain. For $124.50 from Aeromedix and $132.75 from Aircraft Spruce (www.aircraftspruce.com), the Pocket CO 300 is just that—a keychain CO detector. It displays the CO concentration, but does not alarm until it hits 50 PPM, a shortcoming, in our opinion. The alarm sounds at 82 dB, flashes an LED light and vibrates with increasing frequency at thresholds of 50, 125 and 400 PPM. There is no time delay—it alarms upon reaching a concentration threshold. The unit can be turned on to stay on for 12 hours or continuously, at the user's discretion. Our initial impression was that a "keychain" device couldn't be very sophisticated. We were wrong. It tracks total exposure to CO, eight-hour time-averaged exposure, measured maximum exposure and when it occurred.

The Pocket CO will also fire its alarms if the temperature is under 0 degrees C or above 50 degrees C or an internal sensor malfunctions. It is powered by a coin cell battery that can be replaced by the user. The manufacturer recommends that the unit be turned off when actually in a person's pocket—it needs to be open to the surrounding environment.

GASALERTCLIP

Advertised as the world's most popular, zero-maintenance CO detector, the GasAlertClip Extreme is available in two- and three-year versions from Aircraft Spruce. The prices are $159.95 and $272.95, respectively. The target customers for the GasAlertClip are workers in facilities where there is risk of CO exposure and who need a unit that requires minimal training and simple operation. That does a good job of describing the need for an easy-to-use CO detector in a general aviation airplane. It is not designed to be maintained or to have its sensor replaced—use it for the design life and throw it away.

With its industrial-use design, the GasAlertClip is a rugged unit—it has a "concussion-proof housing"—that has a belt clip and loop that allow it to be hung anywhere that is convenient in the cockpit.

The CO sensor has a range of 0-300 PPM. The low-level alarm is set at 35 PPM and triggers a 95 dB tone, flashing LED light and vibrates

HOW CARBON MONOXIDE KILLS

Carbon monoxide (CO) is a product of incomplete combustion of fossil fuels. In a piston-engine airplane, the invisible, odorless gas is emitted in high concentrations when the fuel mixture is richer than peak EGT—one rarely discussed benefit of operating lean of peak EGT is a low level of CO emissions.

When you inhale, oxygen reaching your lungs combines with the hemoglobin in your red blood cells to form oxyhemoglobin. The oxygen is transported throughout your body by your arteries and capillaries and then disassociates from the blood to oxygenate the cells of your tissues and organs. The deoxygenated hemoglobin returns through your veins to your lungs to reload.

Once carbon monoxide gets into your lungs it becomes the schoolyard bully on steroids—it combines with your hemoglobin to form carboxyhemoglobin (COHb) with a bond that is 200 times stronger than oxygen's bond with hemoglobin. CO takes over, effectively putting your hemoglobin out of commission and depriving your body of oxygen. The hyper-strong COHb bond means that even tiny concentrations of CO can kill you through slow poisoning over a period of several hours. That bond explains why it takes several hours to eliminate CO from your body.

COHb has a half-life of more than five hours for someone breathing fresh air. If you manage to put your airplane on the ground and stagger out of the cockpit with a COHb saturation of 50 percent, it will take at least five hours for it to drop to 25 percent. If you are hustled off to the hospital for pure oxygen treatment (mask or ventilator), the half-life of COHb will drop to on the order of two hours. In extreme cases, the patient is put into a hyperbaric chamber with pure oxygen under three atmospheres where the COHb half-life can be cut to a half hour. That still means a significant amount of time to get rid of CO in the body. It doesn't just go away after you step out of the contaminated airplane.

The oxygen-deprivation function of CO poisoning makes it deadly because it attacks the most important parts of your body first—brain, nervous system, heart and lungs. The first symptoms are headache, fatigue, dizziness, vision problems, increased pulse and respiration rates and nausea. Sitting in the cockpit and continuing to breathe even low concentrations of CO means the danger continues to increase as the strong COHb bond causes the concentration in your blood to continue increasing.

In new airplanes, the FAA allows up to 50 PPM of CO in its prescribed test. OSHA originally allowed 35 PPM in the workplace but upped it to 50. The EPA calls for a health alert if outdoor concentrations reach 9 PPM for eight hours or 35 PPM for one hour.

We note that low concentrations of CO in the bloodstream have a higher degree of hazard to pilots because they are exacerbated by hypoxia—a 10 percent COHb concentration is no big deal on the ground (normal for a smoker), but at 10,000 feet it significantly degrades night vision and judgment.

The most common way for CO to get into the cockpit is through the heating system due to cracks in the muffler. We think any in-flight CO concentration of 10 PPM should be grounds for finding the source and eliminating it. If it gets to 35 PPM, we recommend that you go on oxygen if you have it and land as soon as is practical.

PANEL-MOUNTED CO DETECTORS

While we lean toward the convenience of portable CO detectors and the ability to use them to sniff throughout the cabin, they run the risk of being forgotten or lost, making panel-mounted units attractive.

The big dog in the world of panel-mounted CO detectors is Guardian Avionics (www.guardianavionics.com), which makes five detectors for the dash and two remote-mount units. They differ in size and features offered, with one including a pulse oximeter—it should be noted that a pulse oximeter does not detect CO presence in the blood. We surveyed three Guardian units.

At $499 plus a two- to four-hour installation, the Aero 452-101 (top photo) will fit into a 2.25 by 1.5 inch panel opening and weighs 3.5 ounces. It provides CO detection and a cabin pressure warning and the ability to display the information on a long list of PFDs, MFDs and engine monitors. There is no display on the unit itself.

The 452-101 will operate on 14 or 28 volts and has an internal fan to improve sensing. When the CO level reaches 50 PPM and remains for a three- to five-minute span it alarms with a flashing amber LED light and an 85 dB tone. If the CO level reaches 90 PPM it alarms immediately with a flashing red LED and an 85 dB tone. When CO levels are below 50 PPM, a green LED shines continuously.

We are uncomfortable with a unit that does not provide information on low levels of CO as we recommend that if 10 PPM is detected, the airplane should go into the shop and the cause fixed and that if 35 PPM is reached in flight that the pilot should go on oxygen and the flight terminated.

The Aero 551 CO detector (middle photo) is Guardian's most sophisticated detector. At $599, it displays CO concentrations from 10 to 999 PPM and fits into a standard 2.25 inch round instrument cutout. While we like the continuous display of CO levels—that may be caught in an instrument scan—the first alarm does not sound until the level reaches 75 PPM and remains there for five minutes. If it reaches 300 PPM, it will alarm within one minute.

The $699 Aero 553 (bottom photo) retains the functionality of the 551 and is designed to physically replace the panel clock as it has a clock function. In addition it has features that include a flight timer, stopwatch, inside and outside air temperature, battery voltage, cabin altitude and density altitude features on an LED display. It will also display its indications and alerts on a number of third-party avionics products.

The CO detector detects and displays CO levels from 30 PPM to 999 PPM and alarms if the level exceeds 50-70 PPM for five minutes or above 300 PPM for one minute.

Life span of the Aero units is five to seven years. We like that the Aero 551 displays CO levels as low as 10 PPM. Nevertheless, we think that's a bare minimum requirement for any detector. Because of the insidious nature of CO poisoning and the risk of exposure to under 50 PPM over the course of a flight of a few hours, we think all of the detectors should alarm at a level below 50 PPM.

the case. The high-level alarm sounds at 200 PPM. The LED display reads out CO concentration as well as time remaining on the sensor. There is a data logger that records exposures. The exposure data can be downloaded.

We like the GasAlertClip from a simplicity standpoint; however, having to buy a new one every two or three years makes sense when they are bought in bulk for factory or maintenance workers, and it's time-consuming to collect units and send them out for maintenance. However, for a user who is only going to buy one, such as for a general aviation pilot, we think it would be better to be able to send the unit in for refurb.

CHEMICAL SPOT DETECTORS

Stick-on chemical CO detectors seem to have been around general aviation since it was a lieutenant. They are stick-on pieces of cardboard or plastic that contain a circular chemical patch that is said to turn dark in the presence of CO. We found them in prices ranging from $4.50 to $9.95 and marketed under various names including ASA CO-Detector, Quantum Eye Long Life Carbon Monoxide Detector and Sporty's Pilot Shop Carbon Monoxide Detector.

The spot detectors are the butt of many jokes in aviation as, despite the fact most are only good for 90 days—the Quantum Eye Long Life unit claims 18 months—they tend to get stuck to an instrument panel and left there indefinitely. We also hear pilots express questions as to what color is "dark."

Most of the spot detectors have a place for the installer to write in the date the unit was opened. That's all well and good—most don't have anything printed on it that tells an observer the life of the unit. In our opinion, as with the sticker you get in your car after an oil change, the unit should say when it's time to yank it and put in another. We note that the Quantum Eye passes this test as the instructions on its face call for replacing it 18 months after the date opened—and there's space for writing in the date opened.

There is good news—*Aviation Consumer's* testing of the spot detectors a few years back showed that if they were within their expiration date, they would turn dark in the presence

of a CO level of 90 PPM. They don't alarm, just change color, so a pilot has got to include the spot detector in a regular instrument scan and he or she has to make a decision as to whether it's changed color. On that note, we like the Quantum Eye unit because it has a color-coded guide showing normal, caution and danger colors adjacent to the chemical spot.

Spot detectors do not show low levels of CO—something that disqualifies them, in our opinion, from being serious devices. Nevertheless, they are better than nothing.

If your decision is to use one of the spot detectors, we recommend only the Quantum Eye because of its color coding and clear instructions about replacement. We found them for $9.95 at Aircraft Spruce.

RESIDENTIAL DETECTORS

There are dozens of household CO detectors, some with prices not much above those of the chemical spot detectors. We do not recommend any of the residential detectors as most follow Underwriters Laboratories spec UL-2034, which requires a time delay before the unit will alarm once a given level of CO is present. That's to cut down on calls to 911 for false alarms. Under the UL spec, if the unit has a digital readout, it cannot show CO concentrations below 30 PPM. The unit will not sound an alarm until CO reaches 70 PPM and remains there for four hours. At a concentration as high as 400 PPM, the unit will generally not alarm for 15 minutes.

Given the effect of flight at altitude in combination with low-level CO poisoning, we think it's quite likely a pilot would be incapacitated well before a household detector would alarm in flight.

CONCLUSION

Because of its sensitivity, useful life and low-level alarms, our favorite is the CO Experts Model 2016. It's the most expensive unit, but it lasts the longest, so it's not the most expensive in service. The Tocsin came second in line with the Pocket CO a close third.

If the budget just won't cover an electronic unit, then at least get a Quantum Eye, put it where you can see it easily and make sure you replace it every 18 months.

MAINTENANCE TIPS

Control Rigging 101: Check It Yourself, First

Misrigged flight controls can rob speed, autopilot performance and threaten safety. Before bringing it to the shop, make your own assessments.

by Kim Santerre

The chore of rigging the flight controls—which includes, among other things, adjusting control cable tensions—is a maintenance item that's often neglected by owners and mechanics alike. After all, what could possibly change if the airplane has not changed?

But change it does. Parts wear out and clearances change, cables stretch, brackets warp and maintenance of seemingly unrelated systems can lead to unforeseen rigging mayhem.

At a minimum, improper rigging means lost airspeed. At worst, it can mean a lost airplane. In this article, we'll look at the symptoms and describe a do-it-yourself process for checking the rigging on your own. The legwork could save you some shop labor.

HIT THE LOGS

Grab your airplane's maintenance logs and dig for an entry that says something along the lines of: "Control surface rigging checked and found to be in conformity with manufacturer's specifications." We'll bet that you come up empty. If the aircraft has been painted, you might see wording from the paint shop that a control surface has been balanced, but this doesn't mean all surfaces were rigged.

In some instances, an airplane may have been improperly rigged right out of the factory. If it's never been checked, it's still improperly rigged. An especially hard landing can cause a change in the rigging. In these situations, external damage (perhaps wrinkled skin) should be visible, but is often missed. It's possible the damage may be more than cosmetic. Even if it was repaired, it may not be ready for flight.

Got tail damage? Some of the best cosmetic repairs fall short when it comes to rigging effort.

Adjusting control cable tension requires a calibrated tensiometer, a maintenance manual and time. Proper torque setting is directly proportional to autopilot performance. That's a pitch servo in lower photo.

One case of unrelated maintenance and rigging problems involved a Piper Lance. During the course of the repair, the nosegear and engine mount were removed for repairs. New nosegear bushings and straightening/rewelding of the engine mount was accomplished. Reassembled and with the nosewheel centered, it was obvious the rudder was slightly cocked to one side. The new repairs had corrected a past asymmetry problem, which now showed up as the cocked rudder.

Previous damage showed up during a shop inspection of a high-powered twin. It was noticed that the left aileron ground-adjustable trim tab was intentionally bent to nearly maximum deflection, and an extra ground-adjustable trim tab had been installed on the right aileron (it, too, had been bent to nearly maximum deflection). The cockpit-adjustable rudder tab had been adjusted quite far off to one side. Closer examination of the airframe revealed an extra stall strip fitted to the right wingtip.

The wing was bent—apparently in an exceptionally hard landing years before. Attempting to compensate for the asymmetric airframe, mechanics, through the years, had bent the aileron tabs to their maximums. No doubt this airframe wasn't making full speed and its new owner was blindsided with major repairs.

CHECK IT YOURSELF

The specialty tools needed to precisely analyze and adjust the rigging are expensive, but aren't needed for a general status check by non-mechanics. There are early clues: Is the trim tab bent? Do the controls feel stiff? Does the aircraft wander about the roll and pitch axes and is it a chore to accurately trim? It can be argued that observing an aircraft's state of trim is subjective, but there is nothing at all arbitrary about diagnosing an out-of-rig airplane.

Bring the plane to a level area of the ramp where you can run the engine. Verify the ground is level, then level the airplane laterally. You can do this using the leveling points specified in the airframe maintenance manual, although on many aircraft, you can simply put a bubble level across the pilot and copilot's seat tracks. You could also let some air out of one main tire, provided the attitude isn't such that you will have to make one tire flat to level the wings. Be sure the struts are equally level, and that one is not stuck extended or retracted. Don't forget to compensate for the lack of weight in the pilot's seat. Have someone of equal weight sit in for you.

With the airplane in perfect lateral level, adjust the turn coordinator so the inclinometer ball is perfectly centered. This could mean removing the false panel to access the instrument's mounting screws, which are elongated to allow adjustment. Eliminate parallax (the apparent displacement of an object due to a change in the position of the observer) by adjusting the seat to the position you normally have it in flight—and your head in an equally normal position. When you are satisfied the instrument is perfectly level and the ball is centered from where you sit, retighten the mounting screws. If this is a steam gauge airplane, make a similar adjustment to the attitude indicator while it's fully erect. You're only concerned with lateral level here—the airplane may or may not be level with pitch at this point—so don't be concerned with the horizon's pitch display.

Next, make some checks outside the airplane. Get a straightedge of the appropriate length and check each cockpit-adjustable trim tab for fairness. The cockpit indicators may indicate neutral, but they may be lying. Get out and make sure they are actually in a neutral position, which is fair with the trailing edge of the control surface the tab is attached to. If there is disagreement between what the indicators show in the cockpit and the actual position of the tabs, make a note of it and mark the actual neutral position on the trim housing in the cockpit. From the outside of the airplane, make sure that the cowl flaps retract uniformly and completely. Also check for looseness. Note that some cowl flap systems are designed so that the flap trails slightly in flight. Read the manual.

Check the wing flaps and make sure they retract together and come up fairly even. Stand at one aileron-

flap juncture and hold their trailing edges together. Does the outer trailing edge of that aileron line up with the trailing edge of the wingtip? If it does, is the control yoke or stick level? If you see the opposite aileron is level with the flap and wingtip, you may have picked up some valuable clues. A sagging aileron or flap may be the cause of tremendous trim drag. However, unless you have found something terribly awry, check your airframe manual before leaping to possibly erroneous conclusions. For most designs, though, the trailing edges of the flap, wingtip and aileron should fair together to form a straight line or smooth curve.

TIME TO FLY

Ideally you will be flying on a smooth day because bumps will make this more difficult. Fill the fuel tanks and empty the baggage compartments. Use caution, as some aircraft are out of their balance envelope in this configuration, so you might have to compensate. Remember that you are looking to achieve lateral balance in the air. If you nearly always have passengers, then you will want to proceed to check your rigging based on a balanced lateral load (which means taking an equally weighted passenger along). If you fly solo almost all the time, check the rigging based on the unbalanced load of your fanny in the left seat.

Once airborne, accelerate to the normal cruising speed in level flight. Feel free to use the elevator trim, but leave the rudder or aileron trim tabs neutral. Come off the rudder pedals and roll the wings level using aileron (providing a wing was low) referencing the attitude instrument. With the heavy wing leveled and the skid ball centered (without your input), note the rudder trim indicator's position and mark the exact position. Masking tape works. Note whether the heavy wing is still heavy. Chances are it's not, or at least not as bad as it was. If it still takes some aileron input to hold one wing up, adjust the aileron trim to compensate.

Note the aileron trim indicator's setting the same way you did for the rudder trim. On a side note, if your instructor never clued you in, this is really the correct way to trim an aircraft for level flight. Some refer to it as the tail-first method. Trim the elevator to hold proper pitch, then the rudder to get the ball centered and finally the ailerons to get the wings level. This is easier in aircraft with cockpit-adjustable trim tabs or no movable tabs. If the tabs are put into a neutral position and you still find that constant control pressure is required to keep the ball centered and the wings level, the airplane's rigging demands more scrutiny. Its inability to fly straight and level without having one or more trim tabs deflected means it is losing airspeed to trim drag.

Major repairs and performance mods can alter flight control rigging that might be overlooked.

FIX IT, SAVE LONG-TERM

Resist living with an aircraft that's out of proper rigging because the domino effect could cause increased wear on the autopilot and other systems. Slop in control cables could put additional strain on servo motors, while greatly altering the tracking performance of the autopilot. Symptoms may include overshooting (or undershooting) when intercepting a course or approach, pitch porpoising and wing rocking. You might also observe the automatic electric trim running constantly. This is what servo overhauls are made of.

It's difficult to say how much shop labor (and parts) it could take to properly a rig a given airframe. For a machine like a Cessna 210 or Piper Navajo, to name a couple, the teardown alone could have the airplane on the floor for a day or more. Good mechanics follow the rigging procedures in the maintenance manual and use calibrated tools to measure cable tension. There could be some flight testing, too.

Ask the shop doing the rigging if it has a complete set of maintenance manuals to accomplish the job and if it has experience rigging a given type of airframe.

Don't assume autopilot work includes rigging work. While servo bridal cable tensions are set during an autopilot installation, this doesn't mean the aircraft's primary flight controls were rigged.

Last, be vigilant when flying after major airframe repairs. We once flew a rental Skyhawk that required cross-control input to fly straight-and-level after major a wing repair. That airplane was a wreck waiting to happen.

Contributor Kim Santerre is an A&P/IA, Beech Bonanza owner and the longtime editor of Light Plane Maintenance.

ForeFlight 8: New Maps, Logbook, Web Planning

The tablet app used by a majority of pilots gets a new mapping system, but we think it's more potential than practical for now.

by Jeff Van West

CHECKLIST

- Logbook and online improvements expand ForeFlight's capabilities.
- We found that the new mapping system works well, but...
- ...users will likely revert to the old method until the new map better resembles sectional charts.

One of the major announcements from AirVenture 2016 was ForeFlight's version 8. At least it was major in the eyes of the company. ForeFlight CEO Tyson Weihs told us it "might be our biggest release since 2011."

That year marked ForeFlight's first release designed specifically for the iPad, which one could argue changed GA cockpit information forever.

ForeFlight 8 didn't actually release until late August, but we've logged time with a preview version since this summer and only half agree with Weihs. The new version lays the groundwork for huge changes. However, we doubt the day-to-day use of the app will change for most pilots. Not yet anyway. Check out the sidebar on page 19 for more on that. For what's actually new in the app, read on.

MAPS GO DYNAMIC

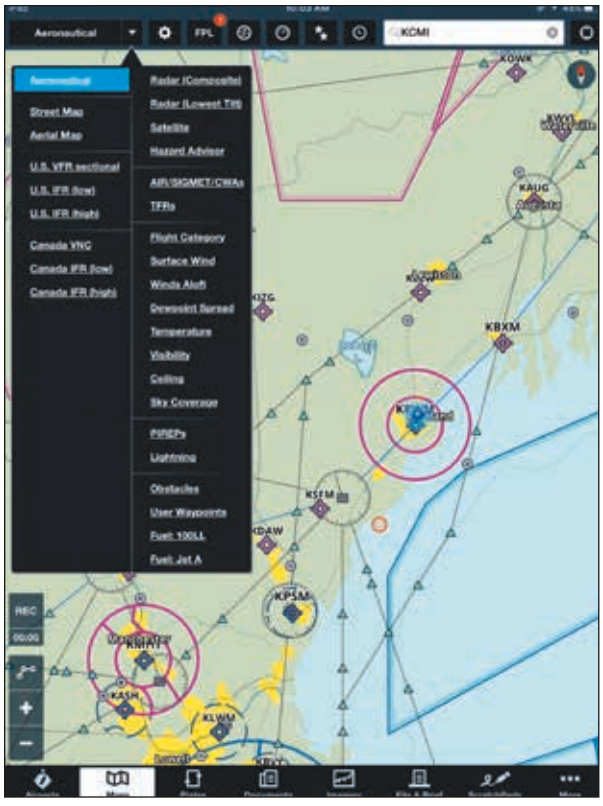
The most obvious change is in mapping. Pilots using ForeFlight spend the majority of their time with a sectional or IFR en route chart as the background, over which they see their aircraft, route, weather and more. ForeFlight has long offered a simple "World Map," showing only state boundaries beneath the overlays of weather or TFRs.

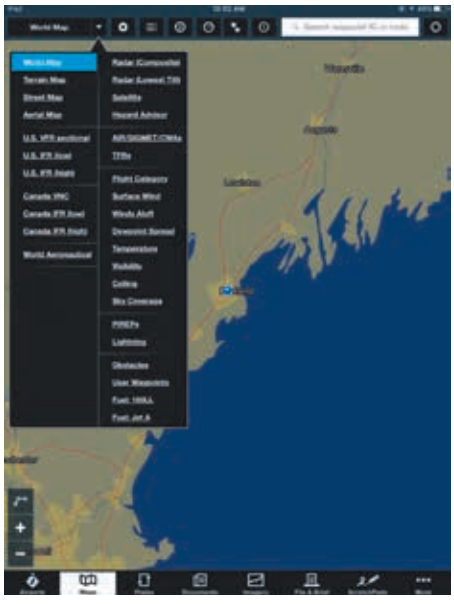
ForeFlight 8 replaces the World Map with a new "Aeronautical" layer. This includes airports, airspace, airways, waypoints, VORs and other critical flight data normally found on a sectional. This data scales and changes dynamically as you pan and zoom the chart, decluttering information as you zoom out and adding information as you zoom in. Labels move as needed for readability. If you zoom in far enough on an airport, you get the airport diagram. Zoom in further and taxiway labels appear.

The effect is similar to the moving map on most MFDs or dedicated aviation portable, the most notable difference being smoothness. In ForeFlight, it's a seamless experience at any zoom level. Dynamic mapping works in any orientation, whereas the text on sectionals is only upright when the map is drawn north-up.

Tapping on a symbol on the Aeronautical layer brings up detailed information just as before, as well as some new features. Tap a dynamically drawn airway and you'll see the MEA and MOCA for that airway segment.

The new dynamically drawn maps also offer day and night themes for ease of viewing under different conditions, as well as customization. You can add terrain shading under the aero data, turn off





The new Aeronautical layer, left image, replaces the old world layer, right, and contains the most critical map data you'd want in flight.

FOREFLIGHT 8 MAPPING AT A GLANCE

Clockwise from upper left: The look and feel of the new dynamic maps in ForeFlight 8 is highly customizable. In the map settings menu, you can choose between a dark theme or light theme. You will also see new Aeronautical Map Settings when the Aeronautical layer is selected. New alerts watch for active TFRs near your current position and provide visual and audible warnings as you approach, and again if you enter one. The alerts work whether or not the TFR is on a chart.

private airports or airspace lines or increase the size of labels for presbyopic eyes. Customization means you can turn off information you wish you hadn't—such as airspace—so use caution when tweaking the chart.

One of the new features is a TFR warning system similar to the runway warnings ForeFlight has offered for some time. If you've downloaded TFRs for your flight area, or have ForeFlight connected to ADS-B data, you'll get a warning of approaching a TFR, or—gulp—being inside of one. More importantly, you'll get it whether or not you have the TFR layer visible on the map.

You'll want to ensure ForeFlight's audio output is routed to your audio panel or headset via cable or Bluetooth for full advantage with this feature. The FAA reports show a marked decrease in TFR violations concurrent with these areas being mapped on EFBs like ForeFlight.

ForeFlight believes the Aero layer will replace the sectional or en route charts for most users most of the time. However, if a user needs something from the full chart, he can turn that layer back on. This draws both the sectional (or en route chart) and the aeronautical info. Users can also turn off the aero layer and just use the traditional chart—and all of ForeFlight—just as before.

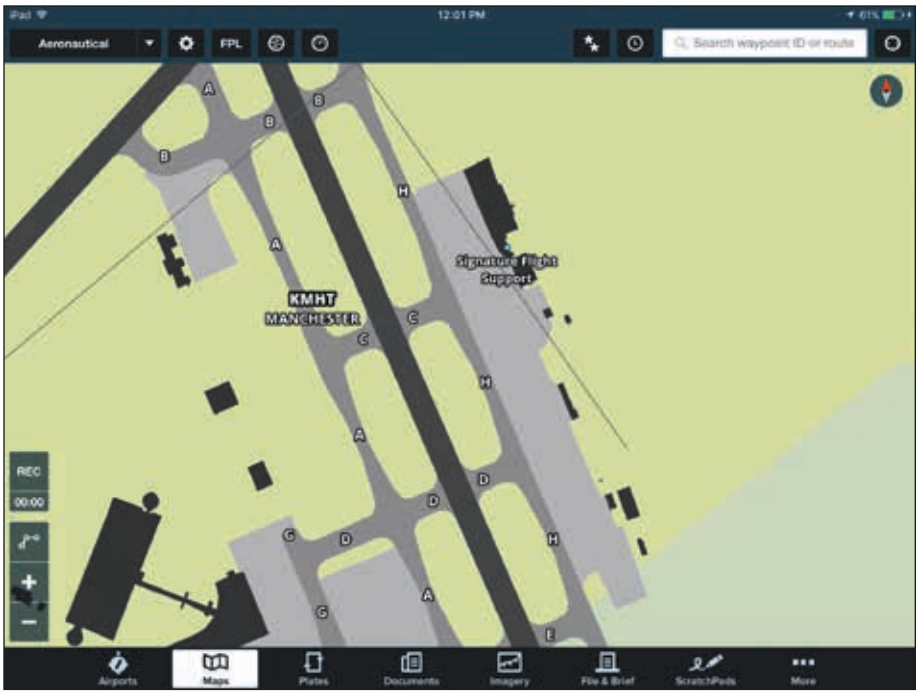
Our opinion is many pilots will do just that (see sidebar on page 19). The aeronautical layer has the critical items most pilots will need for most flights, but it's far from comprehensive. Weihs says that, while the company will still include traditional chart backgrounds for the foreseeable future, the data-driven approach to aviation information is a far more productive experience. For example, the company has been working with the FAA on how data is updated and disseminated.

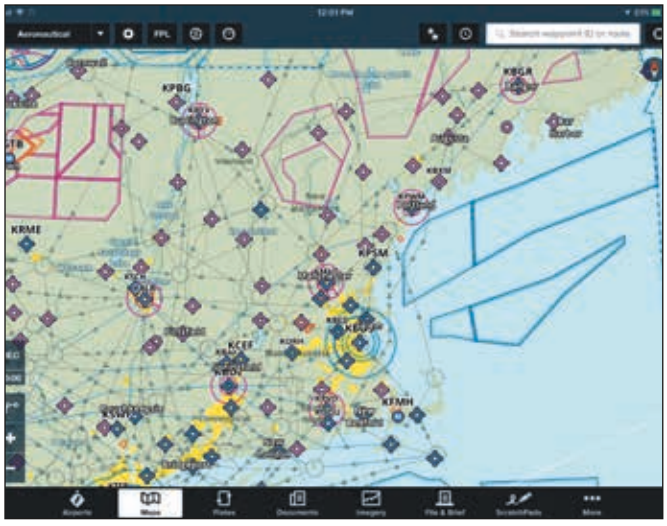
Weihs envisions a day soon where "an airport manager could make a runway closed and 10 minutes later pilots worldwide could see it marked as closed on their iPads." You have to admit, that would be cool.

LOGBOOK, ONLINE PLANNING GET BOOSTS

ForeFlight's previous version offered a simple logbook, but the fact that over a third of ForeFlight users started using the logbook made improving the system a priority for the company. The most notable addition is with sharing of flights. Now you can create a logbook entry, or approve one ForeFlight generates automatically, and send it to another ForeFlight user.

This makes sense with two crewmembers or with flight instruction. ForeFlight also added remote signing for instructors. So combining the two, a student entry could be created, shared with the instructor for sign-





These screen grabs show that the new Aeronautical layer seamlessly zooms to any scale, adding or removing detail as appropriate.

ing and approved such that matching entries appeared in both digital logbooks.

There's also a new logbook API for third parties to access the ForeFlight logbook and generate flights or request data. This might be useful if you're practicing on an approved simulator and want those flights recorded automatically (and correctly) in your logbook.

The overhaul of ForeFlight Web is more significant. ForeFlight's stated goal is matching the online experience with the iPad one, so you could comfortably plan and file from your desktop and simply load the flight plan already synced to your iPad. As part of this, ForeFlight 8 allows planning and filing throughout North America, including intra-Canada VFR and the Caribbean.

Our experience with the online version is that it's acceptable if you happen to be sitting at your desk, but we think the iPad system is still superior. All the important features are available online—selecting specific aircraft, on-screen editing, procedure advisor—but ForeFlight was designed for the iPad and that's where it shines. The sync works both ways, however, so you can also plan on the iPad and then check up on weather or review a chart when you take a break from that sales spreadsheet you're obsessing over.

What we do like better in the web browser than on the iPad are generating 8710 or flight experience reports and reviewing track logs from previous flights. You can also share flights from here, or download a KML file to view in Google Earth or on a debriefing tool such as the CloudAhoy.

IS IT A BETTER EFB?

If you're already a ForeFlight user, the advent of ForeFlight 8 isn't so much an option as a natural evolution. The good news for those recalcitrant to change is you can set the new ForeFlight to look and feel virtually identical to the old one. The other reassuring tidbit is performance of the app seems unchanged for many and improved for others. We happen to own one of the worst iPad versions for ForeFlight performance and saw virtually no difference between version 8 and the latest version 7.

If you're not a ForeFlight user, is this change enough to switch? We think not. Users preferring WingX, Garmin Pilot or another option are unlikely to find ForeFlight's new offering irresistible given the learning curve of a new app and ForeFlight's more premium pricing.

What's more important is the potential of dynamic data for an EFB. Simply correcting information in the app rather than issuing NOTAMs and textual chart updates simply makes sense. Taking it further, a dynamic instrument approach chart could remove or de-emphasize approach categories that don't apply or transitions the pilot isn't flying, greatly simplifying the chart. There's real potential there.

We're heartened that ForeFlight is working directly with the FAA and industry partners (and even competitors through working groups) to create new standards and better data distribution because these fundamental use changes work best when we all settle down on some similar standards. For example, Garmin gave us the PROC button on a GPS navigator, but now everyone uses that label. The best user interface often comes directly from the real-world experience of users. That may be the biggest long-term effect of the thinking behind ForeFlight 8: helping with the information management that's a core part of flying today. ForeFlight is leading the way right now. We expect the industry will follow.

ForeFlight 8 requires a fresh subscription. Customers with existing subscriptions will receive a prorated credit. Visit www.ForeFlight.com.

EVERYTHING OLD IS NEW AGAIN, FOREFLIGHT EDITION

Hang around any industry long enough and you'll enjoy the deja vu of yesterday's news repackaged as today's cutting edge. Sometimes that's avocado green as a stylish color, but other times it marks technology enabling something that was only half successful before.

You could argue this is exactly what's going on with ForeFlight 8 and its new maps system. Wasn't this what AnywhereMap and the Garmin 396 did? Isn't this what WingX originally did and still offers? In fact, didn't sectional and en route charts appear in our tablet apps because users demanded facsimiles of the paper charts?

I remember an AirVenture roughly six years ago, sitting across a bean burrito from one of the app developers listed above as he shook his head, saying he begrudgingly added sectionals to the app. His point was simple: The data-driven map was faster and more versatile, and pilots wanted charts only because they were used to charts, not because they were better.

I countered then the same thing I'll say now: Our aeronautical charts evolved into an effective tool over decades of use. They are a marvel of information density matched with usability. Information density is not the same as information overload. (If you're interested in this topic, I recommend the work of Edward Tufte.)

Sure, there are facets akin to QWERTY keyboard layout (it's not the most efficient layout for typing, but it's what everyone is already used to). Why are all the variations in airspace drawn in only magenta and blue? Now that we're always looking at backlit screens without red cockpit lighting, shouldn't prohibited areas be in red? Well, they could be, but they've always been in blue, so...

However, interacting at once with all layers of information while using a traditional chart exposes us to incidental data we'd never know existed. "Wow, there are some tall towers west of the field." "Look, a VFR reporting point near my destination airport. That could be handy." "Hey, there's a major highway paralleling my route if I fly just 15 miles further north." That information can save our bacon, or at least keep it from getting too crispy..

This came up in during my first ForeFlight 8 demo. By chance, the map scrolled past an area I fly quite a bit and I noticed an alert area and two restricted airspaces were missing. It turned out airspaces had been turned off. With a tap, they reappeared, but the very fact that they could be turned off underscored an issue with dynamic data. It's more rope. That makes it a useful tool, and a potential noose.

When the airspaces popped back up, the restricted areas were painted orange, not the traditional blue. This was intentional. Orange is more logical; it's a warning color. However, generations of pilots know blue could be restricted airspace and it gets their attention accordingly. It's the QWERTY keyboard problem again.

Then again, maybe not everyone. Three different designated pilot examiners have told me new private pilot applicants often treat the sectional chart displayed on their iPad like aviation-themed wallpaper. They've asked pilot applicants for the CTAF frequency for an airport on the chart and watched the pilot tap the airport symbol and retrieve the frequency from the pop-up window—even though the same information was literally at their fingertip before they tapped.

While ForeFlight doesn't release how many users they have, it's likely a sizable majority of active pilots, so we'll see a reaction across a wide range of users. I expect the ForeFlight fanatics will adore it. The company enjoys an Apple-esque, do-no-wrong status to some degree. However, if history repeats itself the bulk of users will play with it for a bit—and then go back to their sectionals. Some may go belt-and-suspenders painting the new aero data over the sectional chart.

At least for a while. ForeFlight might have the critical mass to topple our community fondness for pixel representations of old paper charts. In the end, I think that's a good thing, even a necessary thing.

So I'll place my bet right now: Future ForeFlight releases of ForeFlight's dynamic map will bring back sectional-like incidental data. It will fill back in with a density of information but in a downplayed style that's ready to come to the fore (sorry, couldn't resist) with a tap as it catches your eye. Actually, I expect the electronics will meet us halfway, proactively offering information we likely need, such as highlighting VFR reporting points when approaching an airport without an instrument procedure loaded.

It's possible this round of mapping technology—and the people wielding it—will deliver both the promise of dynamism and the value of dense information design. Let's just hope avocado green color schemes stay off the table. —*Jeff Van West*

LONG-TERM EVALUATION

Flying Eyes Sunglasses: Style Meets Ruggedness

The Flying Eyes prescription sunglasses turned out to be the most durable glasses we've owned. Now, the company answers the call for better styling.

by Larry Anglisano

If you've recently invested in name-brand prescription sunglasses, you know how easy it is to tally an invoice well north of $500. That's what I was ready to do a couple of years ago, but instead decided to install prescription lenses in the Flying Eyes Hawk glasses we originally reviewed in the October 2012 issue of *Aviation Consumer*.

The problem I've always had with the Hawk glasses is styling—you won't win any modeling contracts with these utilitarian frames. This might not matter for action sports and flying missions, but they don't exactly complement business attire. The company's new ComfortStyle line changes all that. More in a minute.

After a $75 trip to my optometrist for some measurements, I sent the Hawks back to Cedar Park, Texas-based Flying Eyes to be fitted with my prescription. The lenses are made by Shamir Optical Industry and fabricated through Digital Eye Lab. My order was turned in less than one week.

I sprung for the transition lenses, which kicked the utility up several notches. On long flying days, they are often on my face during the dark drive home with me forgetting I'm even wearing them. I also wear the glasses inside of a full-face motorcycle helmet and in doing so, trashed them the first time out. The glasses are fitted with extremely thin temples (plus an interchangeable cinch strap) to increase comfort while wearing a headset, but it doesn't tightly secure them to the head. With the face shield up (my bad), a gust of wind sucked them out of the helmet where they survived the impact with the pavement, but not the weight of a speeding six-wheel pickup. Flying Eyes offers a generous replacement/repair cost—$79 plus shipping. Destroy more than two pairs and the price jumps to $149, plus shipping. I had a replacement in a couple of days.

Other than the run-in with the truck, I can't seem to break or scratch these things—and I'm not gentle. I sit on them, drop them from the wing of the airplane, stuff them (unprotected) in a full backpack, wear them in salt water, ice them up while on a snowboard and use them at the shooting range, although I don't want to find out if they're bullet-proof. With UV400 sun protection, I think they perform as well as my military-issued Oakley M Frame.

If you order a non-prescription model and don't like them, the company has a 30-day return policy (with full refund, less shipping).

I've hammered company principal and pilot Dean Siracusa pretty hard about the mediocre styling thing, and he's stood by his promise to add more frames, without compromising durability. I've been wearing the new Golden Eagle and it seems tough.

The new ComfortStyle line, which includes $39 reader frames, plus a variety of models including the Kestrel Titanium Aviator, Golden Eagle sport wrap and other trendy designs, should appeal to both male and female pilots.

The new frames, which start at $96, are shatter and scratch resistant, plus they are available with optional polarization, which I suggest you avoid for cockpit use. The original Hawk model remains in the lineup and starts at $336 when fitted with a prescription. To see the new line, visit www.flyingeyesoptics.com.

The new ComfortStyle line shown here brings modern and more stylish frames to the cockpit.

iPad Panel Mounts: They Beat Kneeboards

Now that the FAA doesn't object, mounting a smartphone or iPad in the panel is practical and safer than a knee mount. Any of the three we reviewed are suitable.

by Paul Bertorelli

CHECKLIST

- All three mounts are quick and hassle-free to install as a minor modification.
- Ship's power can be wired to charge the tablet while operating.
- AirGizmos surface mount in an instrument hole is the cheapest and quickest.

Does there breathe a pilot not using an iPad or tablet of some kind in the cockpit? We may know of one or two, but the rest of us confront this challenge: Where to put the confounded thing during flight? The aftermarket has provided in the form of more mounts, straps, clips, brackets, cases, bags and sleeves than an ordinary human can fathom, much less evaluate for purchase.

In fact, there are so many of these devices that we're breaking them into two categories: brackets and systems for panel mounting and gadgets for strapping them to yokes, knees and the odd windshield or window. In this article, we'll examine the panel-mount options, of which there are a surprising variety.

For those who worry about the legalities, the FAA has recently relaxed restrictions on semi-permanent cockpit mounts for tablets, even products that require a sizable panel hole, wiring or plumbing for cooling. These are generally considered minor modifications and although they require logbook entries, they may not require further documentation.

AIRGIZMOS

AirGizmos made its chops with a line of in-panel mounts for portable GPS units, most recently for Garmin's aera series. The products remain a mainstay for light sport and experimental aircraft, many of which rely solely on panel-mounted portables for navigation and, increasingly, weather and traffic data, too.

For tablet and smartphone mounting, AirGizmos recently added a mount for the iPad mini 4 to products it already had for the iPhone 6 and 6 Plus and iPad Air line. As do many other manufacturers, AirGizmo also offers kneepad type mounts.

These mounts are of two types. The in-panel dock versions fit into the standard 6.25-inch width of a radio stack and present a flush appearance. For the iPhone, the device is mounted horizontally or vertically, depending on the panel space available. The mount, which is molded of ABS plastic, is fastened with screws passed through tabs on the back of the bracket. The phone or tablet snaps into place with a spring locking tab and can be easily removed.

Given that iPads have been known to shut down in flight due to overheating, the AirGizmo mounts have a round cooling port on the back that can accept the output of standard avionics cooling fans. While the cooling might not be necessary for the phone, we would recommend it for the larger tablet, whose display emits more heat. Both the phone and tablet mount have provisions to route a Lightning power cable and audio cable through the standard 3.5 mm jack. For panel docks, AirGizmo's catalog covers the iPhone and mini, but not the iPad, at prices ranging from $79.95 for the iPhone to $129.95 for the mini. AirGizmos' less intrusive solution covers both the iPad and mini line and offers quite a bit of flexibility in mounting. The

FlyPad with iPad mini, right. It can be installed in portrait or landscape mode. The device has a patent-pending slide-and-lock mechanism, lower photo.

AirGizmos mini mount, left, includes a bracket that mounts in a standard instrument hole. The iPad cradle slides onto the bracket and has an adjustable viewing angle.

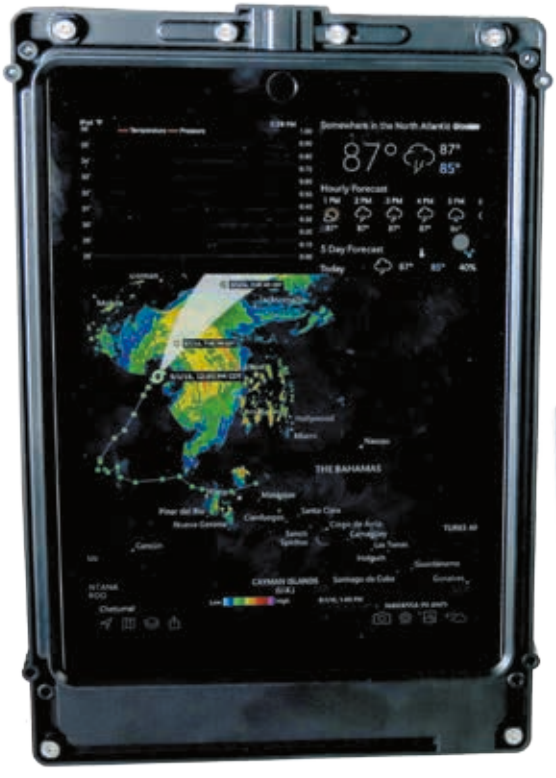
AirMount—not to be confused with the iPad Air—consists of a custom bracket designed to fit into a standard empty instrument hole, secured with the four corner screws. The holder that carries the tablet then mates with the bracket to provide a secure mount. However, AirGizmo considers this a surface mount; the tablet stands proud of the panel, not flush with its surface. These mounts cover the full iPad line,up through the iPad 4 at prices ranging from $59 to $109. The AirMounts mounts can be configured to tilt the tablet slightly to improve viewing.

AirGizmo also offers a suction-mount option for owners lacking the vacant instrument hole. This mount has a strong suction cup equipped with a variable-length, adjustable arm and a quick disconnect for the tablet bracket. The $109.95 bundle includes the cup, the tablet mounting bracket and three arms of various lengths.

AirGizmo sent us samples of these products and we found that the kits are well prepared, packaged with the necessary hardware and are well illustrated with installation instructions and drawings.

GUARDIAN MOUNTS

Guardian Avionics is best known for its line of CO detectors, some of which are reviewed elsewhere in this issue. Earlier this year, it launched a complete series of iPhone and iPad mounts, including accessories such as power supplies and cabling.



Guardian Avionics iPad Air mount, left, and mini, lower, can be equipped with onboard USB power supplies mounted on rear brackets, upper left.

Guardian's iFDR series are all flush mounts and cover the entire Apple line, from the iPhone to the huge iPad Pro that we wonder how anyone could fit into a light aircraft panel. These are designed a little differently than AirGizmos, in that they consist of a solid tray-type bracket that fits flush into a large opening cut into the panel. According to the drawings provided, a hole with radiused corners is cut in the panel and the mount installs from the back of the panel with screws at four corners.

Even for the iPad mini, this will require quite a bit of unobstructed space behind the panel and not just laterally. Although you wouldn't necessarily have to use them, the Guardian mounts can include an optional USB power supply that connects to ship's power. It mounts on a pair of brackets behind the mount and increases total depth to about 2.5 inches. Before purchasing one of these mounts, we recommend downloading the drawings from Guardian's site and probing behind the panel to measure the potential mounting area. In some aircraft, we suspect the clearance won't be available.

The tablet is held in place in the mount by a spring-loaded slider that also carries the male Lightning connector. To mount the pad, you insert the connector, then angle the pad into the mount and push it flush against the slider's spring tension. To remove it, use three fingers to push the tablet against the slider, then ease it out.

On the opposite side of the mount, there's accommodation for an audio cable that's inserted in the same way as the Lightning plug. The iPad's audio output or input for recording can then be tied into the ship's audio system. As with the AirGizmo products, the iFDR mounts are equipped with a round port to accept avionics cooling air. We would recommend using it. The Guardian products ap-

pear to be well made, molded from ABS plastic and the website has complete documentation and drawings. Prices start at $99 for the iPhone ($299 with power supply) to $249 for the iPad Pro or $449 inclusive of the power supply.

FLYPAD

FlyPad takes a different approach to iPad mounting and one well-suited to using the tablet as a primary information source in an experimental aircraft. But given FAA tolerance in allowing these mounts into certified aircraft, we see no reason not to consider it against the other mounts.

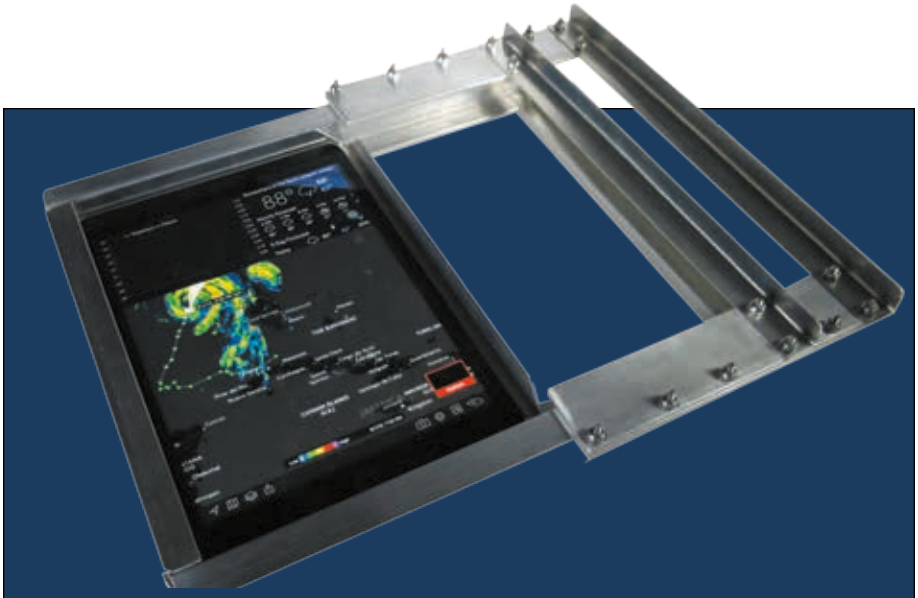
In concept, the flyPad mounts are similar to Guardian's iFDR products. Indeed, they're so similar that we're compelled to report that flyPad plans to pursue an intellectual property case with Guardian, claiming that Guardian reverse engineered the flyPad product to design its own products. FlyPad first appeared in 2013. FlyPad's patent, which applies to the slide-and-lock mechanism, is currently pending, but predates Guardian's entry into the market. Guardian told us it wasn't aware of the challenge.

Although they're similar in principle, there are feature differences between the two products. FlyPad's mounts are machined from solid Delrin while Guardian's are injected ABS. FlyPad says the Delrin is more temperature stable and machining from a billet offers more flexibility to accommodate changes in tablet dimensions with evolving models.

Also, flyPad's solid back allows the option of mounting two steam gauges in the mount itself, serving as a readily accessible backup available by simply popping the tablet out of the mount. It installs similarly to the Guardian design but requires less space and includes accommodation for the Lightning connector.

FlyPad's Crew Feighery told us the flyPad mounts are slightly smaller because they don't use the 3.5 mm jack for audio. Feighery says both audio and power can be piped through the Lightning connector.

FlyPad mounts don't have the cooling option, but the company says owners who have installed the product report not needing the cooling. FlyPad has mounts for the iPhone 5/5S ($179), the iPad mini ($199) and the iPad Air ($229). The iPhone 6 isn't covered because demand for it is too limited.



IPAD STOWAWAY

While not specifically a panel-mount solution, Aircraft Spruce and Specialty offers a device called the iPad Undermount Stowaway. It works like a sliding drawer on a pair of runners that attach under the panel, with a provided aluminum angle to brace the mount against flexing.

To install it, you 'll need depth under the panel with no obstructions such as wiring or hoses and nothing obstructing the slide out of the drawer. The stowaway can be used to get the iPad out of the way or, presumably, use it in place if the viewing angle is acceptable.

If we could suggest an improvement, it would be a set of instructions with better drawings and fewer typos. The Undermount Stowaway is available from Aircraft Spruce for $169.95 and can be used with the iPad Air or the mini, or any comparably sized tablet.

LEGALITIES

When these mounts first appeared for portable GPS six years ago, the FAA had no documented position on their legality. Some shops found approvals under Form 337s and others wouldn't touch them.

The current guidance is found in AC 20-138D and in a policy statement issued by the FAA in 2012. (The reference is PS-ACE-23-01.) The statement refers to a handful of other ACs, but not 20-138D. The policy follows 20-138D's language in allowing installation of a mount on a "no-hazard basis" as a minor alteration. The installer is required to confirm that the installation won't interfere with aircraft controls and/or disturb required systems in the aircraft. The device must also be equipped with a VFR-only placard. (On the Guardian and AirGizmo mounts, the placards are molded right into the mount.)

While some FAA FSDOs may not have gotten the memo on this, the manufacturers of these mounts tell us customers haven't encountered significant FAA resistance.

Our advice is before buying a mount—other than the AirGizmo surface mount products—feel out the shop's view on installing one on a logbook entry as a minor alteration. Better to discover this before you take the plunge. Our view is that odds appear to favor a problem-free installation.

CONTACTS...

Aircraft Spruce and Specialty
877-477-7823
www.aircraftspruce.com

AirGizmos
972-671-800
www.airgizmos.com

FlyPad Mounts
www.flypadmount.com

Guardian Avionics
520-889-1177
www.guardianavionics.com

Cessna 172 Skyhawk

Take your pick from vintage straight tail to ultra-modern glass panel models. None are fast, but most are affordable to fly.

Perhaps one of the most recognizable and most produced general aviation aircraft, Cessna's 172 Skyhawk may also be among the most economical four-placers to own. Sure, there are others worth considering, including the Piper Warrior, Beech Sundowner and even a Grumman Cheetah, but Skyhawks tend to be favored by flight schools. This makes more of them—including modern glass panel-equipped models—available on the used market. And there are plenty of Skyhawks of various vintages to chose from.

While the Skyhawk is a dated airframe that won't turn heads on any ramp (brand new ones included), the airplane delivers enough for the money to earn its keep.

Even if you bottom feed and end up with a project airplane that begs for mechanical and cosmetic attention, chances are it will take only a modest sum to bring it to airworthy status. It might not be the fastest, the most aerodynamic or poshest ride around, but one thing is certain: The Skyhawk delivers enormous practical value for its highly affordable purchase price.

For this reason, you won't need to look far on any ramp or used airplane ad to find a Skyhawk. During its original 31-year production run, a total of 35,773 Skyhawks were built and well over 20,000 of those are still flying in the U.S. The fact that Cessna could reintroduce and continue to build and sell such a stale design (not to mention the existence of extensive aftermarket refurb programs) compared to flashy composite speedsters that dominate the market says that buyers resonate with the Skyhawk's many strong points.

Folks who buy Cessna 172s tend to be honest about the airplane's attributes and limitations.

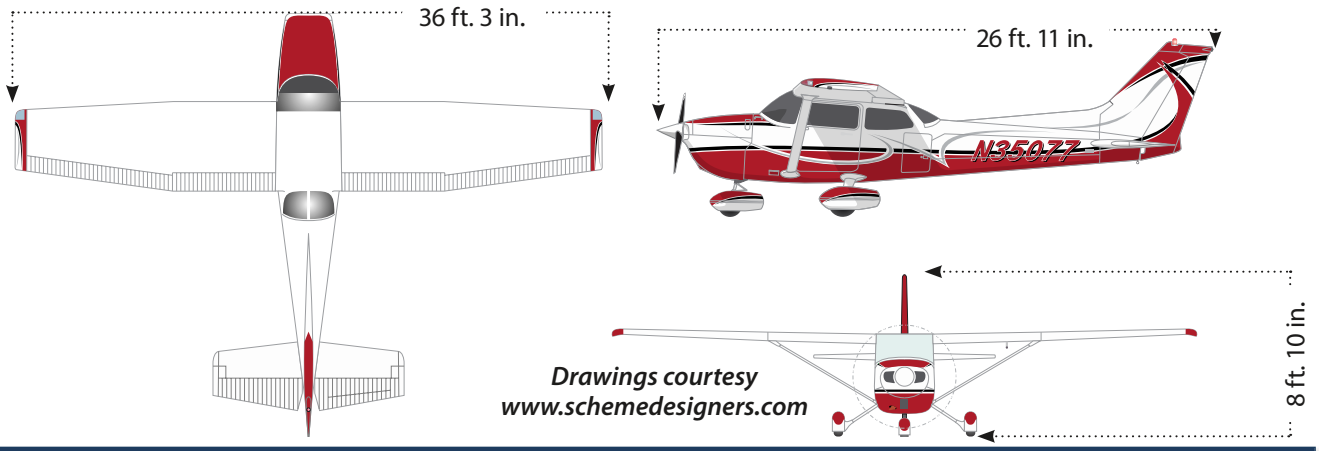
The performance and economics are compelling. The airplane chugs along at an honest 115 knots, burning under 10 gallons per hour while carrying a reasonable load. Just don't be in too much of a hurry to get where you're going in a Skyhawk — it's no speed demon.

While a 172 is an easy airplane to fly by most standards and has a low fatal accident incidence, surprising is the number of student-involved runway prangs we uncovered in the NTSB reports. For that reason, while we think a 172 might be an excellent first airplane to own, we also think it makes a poor primary trainer.

Most owners are enthusiastic about their rides. Nearly all boast of an easy-to-afford set of wings that can easily haul family, friends and gear. Many fly hard IFR and brag of a stable instrument platform. As one owner put

That's Dennis Wolter's 1973 172M Skyhawk in the lead photo. According to his calculations, all-in yearly operating costs are around $153 per hour.

CESSNA 172 SKYHAWK

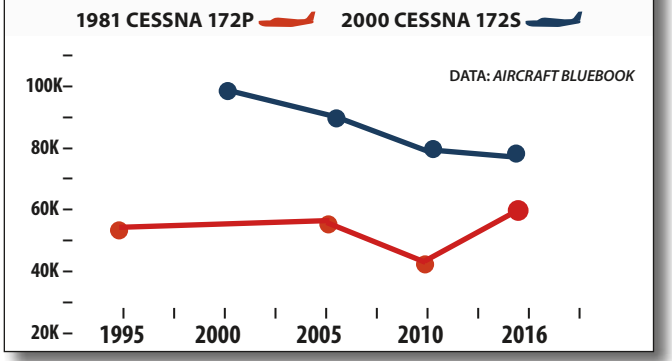


Drawings courtesy
www.schemedesigners.com

SELECT MODEL HISTORY

MODEL YEAR	ENGINE	TBO	OVERHAUL	FUEL	USEFUL LOAD	CRUISE	TYPICAL RETAIL
1956-1959 172	CONT. 145-HP O-300-D	1800	$21,000	40	940 LBS	108 KTS	±$19,000
1960-1961 172B	CONT. 145-HP O-300-D	1800	$21,000	40	875 LBS	114 KTS	±$22,000
1962 172C	CONT. 145-HP O-300-D	1800	$21,000	40	920 LBS	114 KTS	±$23,000
1964 172E	CONT. 145-HP O-300-D	1800	$21,000	40	970 LBS	114 KTS	±$25,000
1968 172I	LYC. 150-HP O-320-E2D	2000	$20,000	40	1000 LBS	115 KTS	±$29,000
1973-1976 172M	LYC. 150-HP O-320-E2D	2000	$19,000	40 (50)	970 LBS	115 KTS	±$38,000
1977-1980 172N	LYC. 160-HP O-320-H2AD	2000	$13,600	40 (50)	850 LBS	120 KTS	±$40,000
1981-1986 172P	LYC. 160-HP O-320-D2J	2000	$13,000	40 (64)	950 LBS	120 KTS	±$65,000
1997-2000 172R	LYC. 160-HP IO-360-L2A	2000	$17,000	50	860 LBS	122 KTS	±$80,000
1999-2005 172S	LYC. 180-HP IO-360-L2A	2000	$17,000	50	890 LBS	124 KTS	±$115,000
2011-2013 172S(SP)	LYC. 180-HP IO-360-L2A	2000	$25,000	50	890 LBS	124 KTS	±$270,000

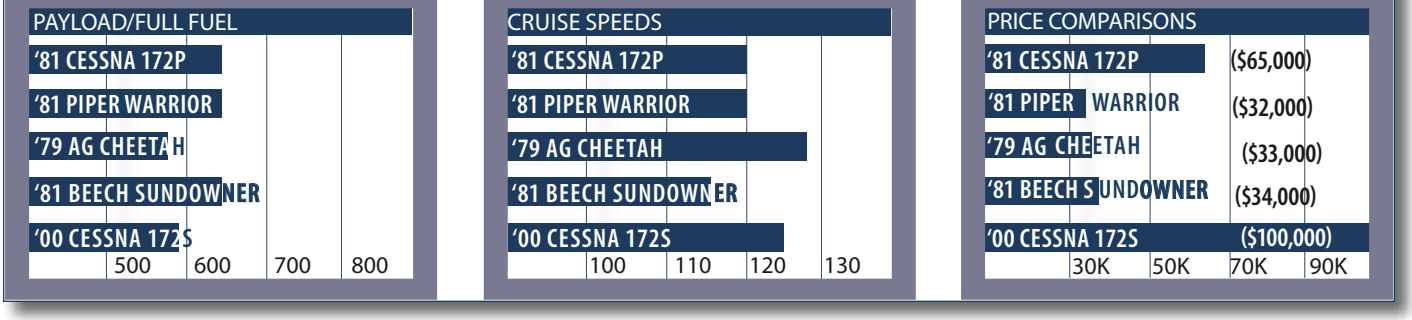
RESALE VALUES



SELECT RECENT ADs

AD 08-26-10	ALTERNATE STATIC SELECTOR VALVE
AD 08-02-18	PICK-UP COLLAR SUPPORT AND SCREWS
AD 04-19-01	SHOULDER HARNESS ADJUSTERS
AD 99-27-02	FUEL SELECTOR VALVES
AD 97-01-13	FUEL, OIL AND HYDRAULIC HOSES
AD 08-05-09	CREW SEATS (172R/S ONLY)
AD 08-03-02	FUEL RETURN ASSEMBLY (172R/S ONLY)
AD 07-08-03	FLEXIBLE FUEL HOSES (172R/S ONLY)
AD 07-05-10	CREW SEATS STEEL LOCK ROD (172R/S)

SELECT MODEL COMPARISONS



The Ascend 172 comprehensive refurb by Yingling Aviation, shown here, is a high-end, custom modernization program for N-model Skyhawks.

it, "It's tempting to step up to something with more speed and creature comforts, but my Hawk is predictable in every aspect of ownership."

MODEL HISTORY

The 172 legacy started in 1956. Actually, it was the tail-dragging model 170A that planted the 172 seed back in 1949. The 170A was a fabric-wing machine that suffered from poor roll response since its ailerons were carried over from the smaller Cessna 140.

The 172, of course, is a true tricycle gear airplane. What was going to be the 170C ended up with a nosewheel on it. Obed Wells, Cessna's project engineer on the 170, was concerned that the 170C had a rear fuselage that was too weak and shouldn't be used as a tailwheel airplane. Piper's Tri-Pacer, the first trike to sell in serious volume, was a hit because it was easier to land and taxi, which is what budding pilots wanted. Then as now, mastering a conventional gear airplane without an excursion into runway edge ditches was a difficult challenge.

The tricycle gear promised to simplify training and it was thought to be the design of the future. But not everyone saw it that way, least of all the established movers and shakers at Cessna. Nonetheless, some at Cessna saw that there was a place for a tri-gear airplane and they began to develop one, albeit without the official blessing of the company's management. In fact, if the behind-closed-doors tri-design wasn't stashed away for future use, the 172 as we know it today may never have come to market.

The R&D effort that became the 172 was conducted at an isolated farm strip well away from Cessna's main operations in Wichita. The prototype's first flight occurred in June of 1955 and although it was successful, a list of concerns surfaced.

There were worries about controllability versus stability, ground handling concerns plus fear of propeller strikes, yaw or directional stability and the need to ensure enough elevator power to overcome the high thrust line, which tended to press down the nosegear, aggravating the prop strike problem. Further, the firewall had to carry both the engine's weight and the nosegear attach point, which Cessna engineers knew would take a terrific beating at the hands of ham-fisted pilots. Other questions arose related to centering the nosewheel in flight and figuring out how to keep the wheel from shimmying like crazy on landing and takeoff. This was uncharted territory for Cessna and had been non-issues for familiar tail-dragging designs.

MODERN GEAR

The 172 main and nosegear that emerged from these deliberations formed the foundation for what became Cessna's standard fixed-gear design. The gear was made fairly short to lower the center of gravity and minimize porpoising and ground upset. A total of 2318 landings were made during the test program by a number of pilots with widely varied experience.

This resulted in what Cessna marketing mavens called the "Land-O-Matic" gear and Cessna's promotion soon reflected its new devotion to tricycle gear design. The ads touted that you "drive it into the sky and drive it into the ground." Unfortunately, the latter part of that phrase came to have a double meaning. In truth, getting the landing gear right was not quite so simple and it took some effort to improve the 172's crosswind and ground handling habits.

The 172 as introduced in 1956 was powered by a Continental O-300-D six-cylinder engine rated at 145 HP turning a fixed-pitch propeller. Gross weight was 2200 pounds. The original 172s had an upright vertical stabilizer and a straight-backed fuselage which, to the modern eye, looks dated. But that wasn't so in 1956 and Cessna moved 1100 172s that year.

Then began what would become a proliferation of model changes and improvements, including the long hibernation between the mid-1980s and 1997 that brought the technically advanced Skyhawk still in production today. More on that in a bit.

The 172A, with the vertical tail swept, was introduced in 1960. The new empennage was heavier; rudder power was reduced and directional stability was degraded somewhat all in favor of marketing. The fastback fuselage blended with the swept tail looked cool.

If a G1000 Skyhawk, top, is out of the budget, you can build your own glass avionics suite starting with a new instrument panel, middle. Steve Mayotte's clean steam gauge panel, bottom, is still well-equipped for IFR, if not utilitarian by comparison.

The 172B was developed for the 1961 model year. The landing gear was shortened by three inches to improve crosswind and taxi handling, while the motor mounts were raised by the same amount to retain propeller ground clearance.

A baggage door was incorporated for the first time and the "Skyhawk" name was introduced. Most pilots use 172 and Skyhawk interchangeably and in later models the two did become one. But early on, just like in the car market, there was a distinct difference in trim and equipment levels.

In 1963, the "Omni-Vision" rear-window 172D version was introduced. To help overcome the squirrelly handling, the span of the horizontal tail was increased by eight inches. The center strip in the windshield was eliminated and along came the one-piece windshield, which improved the view out the front. An optional child's seat for the baggage bay was introduced and gross weight was increased another 50 pounds to 2300 pounds.

Skyhawk models 172 E through H (1964 -1967) featured improvements such as a nosegear stroke shortened by three inches and the F-model came with electrically operated flaps. Many lamented the passing of the manually operated versions because these were more precise, less distracting and easier to maintain. The competition from the other side — the Piper Cherokee—maintained the simplistic manual flaps.

POWERPLANTS

A significant change occurred with the 172I in 1968: The Continental six-cylinder engine was dropped in favor of the Lycoming 150-HP O-320-E2D, one of the most prolific engines ever made. In addition to a new cowling and motor mounts, the new engine package got an oil cooler.

In late 1967, production of the 172 stopped for roughly six months and the 177 replaced it. Market acceptance was not good and there were a bunch of landing accidents.

Still, in repeated head-to-head fly-offs, the heavier 177 outclimbed and outran the 150-HP 172. Cessna's reaction was to move fast to create a new 172 using the 150-HP Lycomings bought in quantity.

The 172K of 1971 dropped the famed—and successful—Wittman spring steel main gear in favor of tapered steel tubes that provided more fore and aft flexing to supposedly improve ground handling on rough surfaces.

The landing light was moved from

CESSNA 172 ACCIDENTS: LANDINGS

The Cessna 172 has long had a reputation as one of the safer airplanes ever built. Our scan of the 100 most recent Skyhawk accidents gave results consistent—there were few fatal accidents. In fact, one pilot who tried to commit suicide by flying into the side of a mountain was unsuccessful.

However, we were amazed at the number of landing-related accidents: 65. We've been doing accident scans in conjunction with Used Aircraft Guides for decades and we can't conveniently recall an airplane that's had a worse landing accident record. The only airplane that tied the 172 was the Cessna 195.

We recognize that the 172 is a popular trainer. Some three-quarters of the landing accident airplanes were being flown by student pilots. We then looked at accident scans we'd done on other airplanes regularly used as trainers. The landing-related accident rate for Cessna 150/152 was 36 percent; for the Piper Warrior 28 percent; Piper Archer, 28 percent; and for the Citabria/Decathlon, 38 percent.

The last time we did an accident scan for the Cessna 172 was 2010. In it we observed a landing-related accident rate of 49 percent.

We do not have an explanation for a landing accident rate that is on the order of twice that of other trainers and higher than an airplane that is regularly used for tailwheel training.

We noted that a number of the landing accidents described pilots who had landed either "flat" or hit the nosewheel first, and then proceeded to porpoise (pilot-induced oscillation) and damage the airplane.

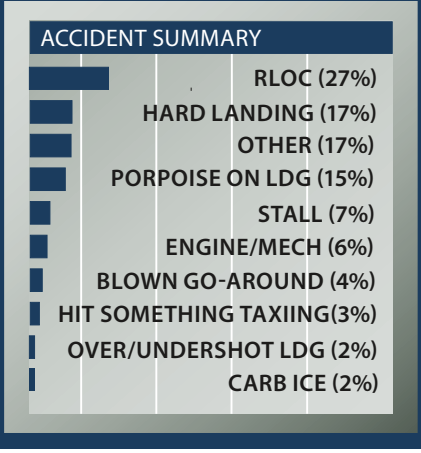
The 172 is near the forward limit of its center of gravity when only the front seat or seats are occupied. That places it at the point in its envelope where it is most difficult to flare for landing.

While that's true for most four-place airplanes, we can't help but wonder why students seem to have more trouble flaring appropriately in the 172 than they do in a PA28-series trainer. Also, why are they more likely to porpoise after touchdown than in a Cessna Cardinal, which has a reputation for that particular problem? (The Cardinal's landing-related accident rate in our most recent scan was 39 percent.)

Looking beyond landing-related accidents, we were impressed by the fact that there were only three fuel-related accidents—two pilots didn't discover or drain water that was in the tanks and one pilot ran out of fuel. The fuel system allows the pilot a choice of selecting one or both tanks. The absence of fuel-related accidents with that system speaks highly of it, especially when we see two to four times that many in our scans of accidents of aircraft that do not have a "both" position on the fuel selector.

We were also impressed by the low number of engine stoppages. Of the six, two involved improper cylinder replacement; the other four were unexplained. We expected to see a half-dozen CFIT, VFR into IMC and/or spatial disorientation accidents. There was only one—a CFIT at night with a student and instructor who apparently had no charts.

Until now, we've thought of the 172 as the definitive plain vanilla airplane. After our two most recent accident scans, we now question whether it should be used as a primary trainer.



the leading edge of the left wing to the nosebowl of the cowl, which improved airflow over the wing at the expense of more complicated cowl removal and sharply reduced bulb life, probably due to engine vibration.

In 1972, the 172L emerged with an extended dorsal fin to improve longitudinal stability, making it more difficult to enter a spin. But closer to the ground, 172 pilots typically approached and landed too fast and the accident record bears out that observation to this day; runway prangs due to off-speed landings are a common accident scenario.

In 1974, cruise performance was improved through an effort to reduce drag and improve airflow through the cowling. This turned out to be a greater improvement than many of the other changes. At 8000 feet, 75 percent cruise increased from 113 to 120 knots, although owners say the lower number is more realistic and most plan for even less, around 100 to 105 knots. This suggests that if Cessna had paid more attention to aerodynamics than to perceived market movements, the 172 would have performed better than it does, at least with regard to cruise. Environmental awareness soon caught up with GA as the Skyhawk continued to evolve.

With the mandated change to low-lead fuel, engines designed to operate with 80-octane fuel showed various signs of distress. Lead fouling of plugs and valves rose to epidemic proportions. Deposits caused hot spots that led to premature failure of engine components. Fuel system elements deteriorated because of new and incompatible aromatics and other additives.

ENGINE DISASTER

The Cessna and Lycoming solution turned out to be ill-starred at best, a disaster at worst. In 1977, the 172N was fitted with the now-infamous O-320-H2AD. It had 10 additional horsepower that yielded a higher service ceiling and a knot or two of added cruise speed, but these improvements came at horrendous cost. The engine was a maintenance nightmare. Because of poor lubrication in the valve train, cold starts in cold weather caused tremendous damage to cams and tappets. The spalled metal tended to quickly trash bearings, oil pumps and other components.

The fuel-injected Lycoming IO-360-L2A, photo above, was a welcomed engine when Cessna started building Skyhawks again in 1997. No more carb icing.

Cessna and Lycoming supported owners to a generous degree, as aviation goes, but it took a long time to understand the nature and cause of the problem and to devise ways to alleviate it. More than 5000 of these engine/airframe combinations were built.

There are three major ADs on the H2AD engine and resale value of the airplane is dependent on compliance. AD 77-20-7 calls for replacement of the tappets, AD 78-12-8 calls for replacement of the oil pump impeller and AD 78-12-9 (the big one) mandates replacement of the crankshaft.

It's critical that these ADs be checked. We think it's unlikely that any 172s are still out there sporting unmodified H2ADs, but the logs ought to be reviewed, nonetheless. In 1981, the troubled H engine was replaced in the 172P with another model, the O-320-D2J engine that yielded relatively good service. This is the last of the original Skyhawks and the line was history in 1986.

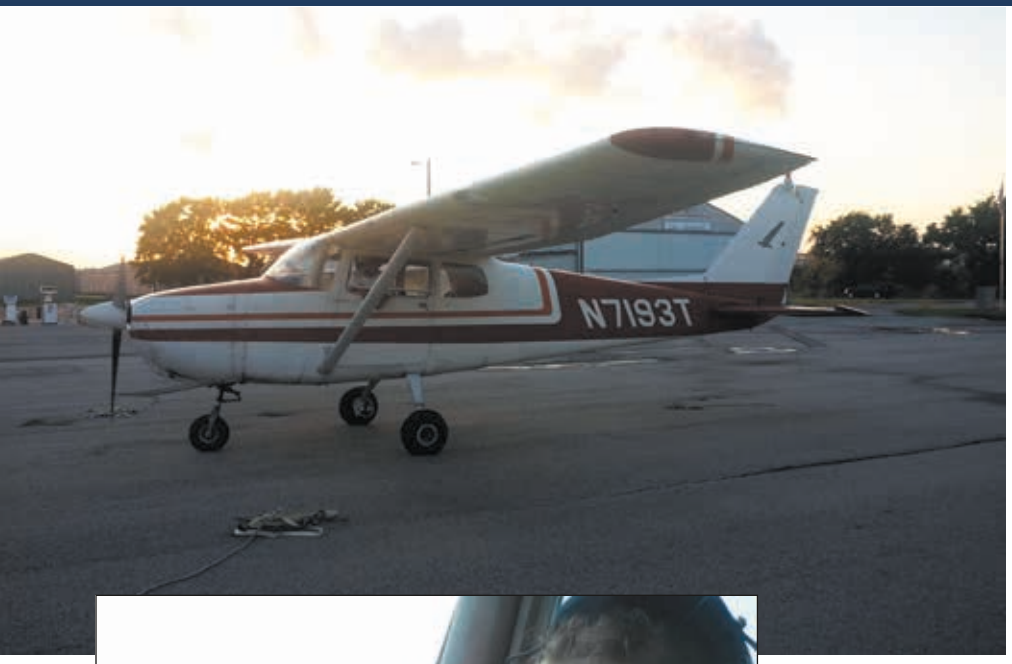
THE MODERN SKYHAWK

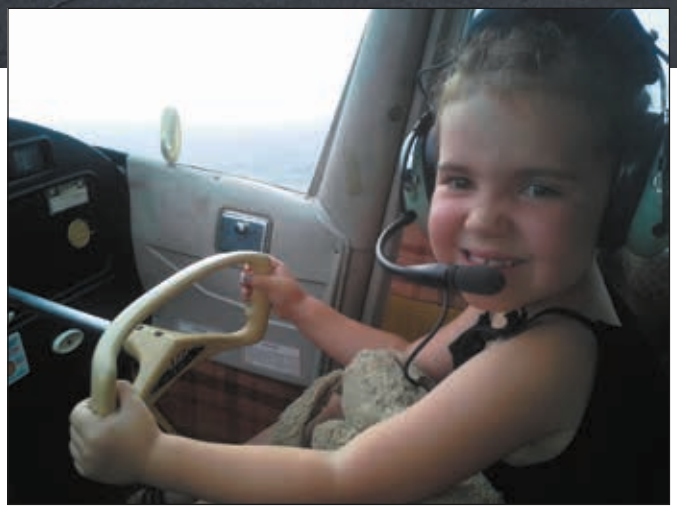
Cessna Chairman Russ Meyer stood by his promise to restart piston single-engine production if Congress passed liability reform. Turns out he's a man of his word. The Skyhawk was reintroduced in 1997 as the 172R and sold for about $135,000 with average equipment including the new Silver-Crown Plus line of avionics—a launch product for BendixKing that proved to be doggy. While modern for its time, this gear was plagued with problems and it's not uncommon to find an airplane that has had a radio stack replaced multiple times.

Although produced under the same type certificate, the airplane has a long list of improvements, including a metal panel, refined seats, better seatbelts, better ventilation and improved anti-corrosion treatment. The mid-2000s model line brought the 172S with Garmin's G1000 integrated avionics suite and eventually the hugely capable GFC700 autopilot. While it had its growing pains, the G1000 was a vast improvement over the BendixKing gear and brought the 172 into the world of glass.

The biggest change was the fuel-injected Lycoming IO-360-L2A in place of the carbureted variant used in the last production Hawks. This change reduces the likelihood of carb ice, but some owners complain that these engines can be tricky to start.

Cessna shot itself in the foot on quality control. Owners of these





Need an honest airplane, plus a college fund? A 1959 fastback, swept tail 172A might be your ticket to affordable fun.

newer aircraft were peppered with ADs and service bulletins totaling no fewer than nine for the 172, including exhaust system problems, firewall problems due to shoddy assembly work, engine oil pressure switches, missing rivets and bad bolts in control yokes. Cessna stood behind these fixes, but all things considered, owners we talked with clearly preferred better quality in a new airplane. In our estimation, that quality has been ramped up. An owner of a 2014 172SP recently told us his ownership experience has been quite good and there has been very little in the way of unscheduled maintenance events in several hundred hours of operation. The owner of a busy flight school who operates more than one newer Skyhawk had similar comments.

PERFORMANCE

Folks who buy Cessna 172s tend to be honest about the airplane's attributes and limitations. Most consider the 172 a two- to three-place airplane with room for baggage and with acceptable (although not exceptional) performance and range. Most owners say 8 GPH is about right for fuel burn, with a little more for the newer 172s, especially the SP. One hundred knots is about right for IFR planning speeds.

Loading a 172 requires some attention, but it's relatively generous in CG range and regardless of loading, there are few complaints about the handling qualities. Pitch forces are the highest of the three axes, but good speed control minimizes this. Properly flown, the 172 can handle stiff crosswinds. Improperly handled, it suffers a high level of landing accidents.

Despite NTSB reports littered with loss of directional control, prop strikes and nosegear failures, the 172 has few vices. It has proven itself as a forgiving airplane that has enabled many people to be pilots who otherwise wouldn't have made the cut.

One of the great strengths of the 172 is its comfort. While its dimensions aren't generous, for all but the longest or widest of pilots and passengers, it's comfortable. For sightseers, the backseat of a Skyhawk is one of the best places to be. Seats in earlier (and unmodified) models are somewhat skimpy and uncomfortable after a couple of hours. In later models, both the comfort and adjustability of the seats are quite good.

Most owners, particularly those who've had their Skyhawks for a few years, report low annual costs. Compared to other brands, Cessna parts are reasonably inexpensive and used parts are normally available in abundance, if needed.

For a design so old and with so many airplanes operating, the number of SDRs and airworthiness directives is surprisingly small, even considering Cessna's problems with late-90s production quality. Skyhawks are notorious leakers of rain, especially around the windshield. Rigging and condition of control cables, pulleys, fairleads and fittings should also be carefully checked.

Many 172s have been poorly or improperly rigged over the years. Corrosion has been found between cable strands and this isn't always visible. Things like this tend to be disguised by a new paint job rather than fixed. The design is notorious for poor nosegear shimmy damping.

MODS, OWNER SUPPORT

Fifty years ago, the general aviation industry was busy putting the tailwheel in front. Now, there are modifiers to put the nosewheel in the tail. Things have come full circle so you can now undo Cessna's work and turn the 172 into a 170. There are countless other mods, too.

Some owners feel flap and aileron gap seals pay off both in low-speed handling and improved cruise. Others say there isn't any difference. Others swear by 180-HP engine upgrades to up the ante in climb performance.

Some of the more popular mods included STOL kits (www.springaviation.com), (www.hortonstackdoor.com), (www.sijet.com) and engine upgrades from Penn Yan Aero (www.pennyanaero.com), Air Plains Services (www.airplains.com) and Isham Aircraft (www.planetools.com). Auxiliary fuel tanks are available from

Flint Aero (www.flintaero.com). PowerFlow exhaust modifications are also available (www.powerflowsystems.com).

Cessna Pilots Association (www.cessna.org), which has an insurance program, monthly magazine and fly-ins, is an excellent tool for all kinds of support. The association runs a variety of type-specific maintenance and operational clinics, including sessions on owner-performed maintenance.

WHICH MODEL?

Mods or not, if you're not considering a newer 172, which of the many model variants is best? For basic day VFR flying, we think an earlier 172 is a good buy. The original Skyhawk with the straight tail and "fastback" fuselage is the best handling, say those who know the breed. The O-300D is unquestionably one of the most successful and comparatively trouble-free engines ever to come from Continental.

Self-proclaimed Cessna experts might say it's easy to pick the worst 172: the notorious O-320-H2AD-engined 172N. However, thanks to mods, overhauls and information about the engine, this model's horrors have receded into the past.

If price isn't the major concern, a used S-model G1000 ride is desirable. For less, the 172P could be the ultimate model to pick, in our view. It has a proven and reliable powerplant and represents good value for the money. But check the logs for an airplane that's been beat up in flight school operations. Understand, too, that you'll likely need to upgrade the avionics and likely the cosmetics—a big expense that will make the airplane better.

Speaking of making an older Skyhawk better, that's what Wichita, Kansas-based Yingling Aviation (www.yinglingaviation.com) is setting out to do with its Ascend 172 refurbishment program. Focusing on N-model Skyhawks, Yingling extensively remanufactures the aircraft to like-new standards. This includes a firewall-forward dyno-tested engine and propeller overhaul (it includes new engine accessories and engine mounts), all new wiring, plus a variety of major avionics upgrades. We looked at its latest completed project and were impressed with the workmanship—including the $20,000 custom paint work and an impressive interior.

Yingling's Jerry Picket told us the company is in the process of redefining the "standard" Ascend, based on buyer feedback. It originally partnered with AOPA on the project with a goal of keeping the price as low as possible (by using analog instruments, as one cost-cutting plan), but quickly learned that buyers wanted an ultra-modern glass panel. Expect to pay $200,000-plus for some Ascend models.

Yingling offers the choice of a 160-HP or 180-HP engine, but hasn't decided which will be the standard. We'll look closely at the Ascend program in a future article.

OWNER FEEDBACK

I have owned a 1978 172N for 22 years. I fly it roughly 50 hours per year in VFR and light IFR conditions. My airplane came equipped with 52-gallon fuel tanks, which is good for six hours of flight with no reserves, burning 8 GPH. I highly recommend that option. I installed a PowerFlow Exhaust, which improved climb performance. Cruise speed is around 120 knots true.

I find that the plane is very easy to fly and is extremely difficult to accidentally put it into a spin. You can slow from cruise speed to landing speed very quickly. Plus, with 40 degrees of flaps hanging out it can easily land on short runways, aircraft carriers or parking lots.

My Skyhawk has been very dependable and economical. The notorious H2AD engine has not been a problem. It lasted 1850 hours before needing overhaul. My annual inspections run around $1300 per year and repairs are infrequent and inexpensive. Insurance runs $658 per year for $1 million liability and $65,000 hull coverage. I do have some filiform corrosion in a few places (the plane used to live in Florida), but this does not seem to be an issue.

All things considered, a Skyhawk is not fast and it's not sexy, but it is safe and dependable. It's also perfect for flights under 500 miles.

Richard Levy
Bell Canyon, California

Owning a 172 is a little like marrying the girl next door. Sure, there's always a prom queen out there, but

The Aviation Consumer

USED CESSNA 172

(continued from page 31)

you probably stand a better chance of knowing what's ahead with the girl next door. I think I knew what I was getting when I became the owner of my 1973 Cessna 172 in 1978. And the longer I own the airplane, the more I am impressed by its many qualities.

My flying horizons have expanded over the years. Whether for local business trips or long flights out west for pleasure, I've flown numerous trips at high altitude, frequently in instrument conditions and sometimes landing at unapproved airports. The 172 always performed as expected. I appreciate its stability as an instrument airplane and its capability in windy conditions. This airplane came with very simple systems and a reliable Lycoming engine. I believe a key component in the success of the 172 lies in the wing and airfoil that Cessna chose way back in 1949. I have flown more than 2000 hours in 172s since 1963, and have never felt near the edge of the wings' ability to do what they are designed to do. Having owned and flown some short-wing airplanes, I always feel comfortable at high density altitude airports as I look down the leading edge of my 36-foot wingspan.

I've been an airport bum since the late 1950s and have made my living working on general aviation airplanes since 1973. I've never met a certified airplane I didn't like. Putting all of that into perspective, the old keep-it-simple philosophy has served the 172 and its owners well.

With a fixed-pitch metal prop, easily removable aluminum fuel tanks and two pieces of tapered pipe for a main landing gear, maintenance costs are both reasonable and predictable. Without question, the biggest expenses I've incurred have been expendable items such as oil changes, spark plugs, 500-hour mag checks, tires, brake pads and occasional nosegear seals. In the past 40 years, the only airframe repair I had to deal with was a fuel leak caused by a crack at the base of the left tank filler neck. Being an A&P and IA, I normally do two annuals myself and have every third inspection performed by a local shop; a second set of eyes can occasionally see some interesting things. The shop-performed inspections generally run between $1100 and $1300, depending on what they find that year.

Yearly operating costs for my 172 with its 180-HP Lycoming engine (based on 70 hours of use) have consistently been about $153 per hour. My calculations include hangar rent, insurance, annual inspections, fuel, engine reserve, plus reserves for paint, avionics and interior upgrades. One number I've left out is opportunity cost, at 5 percent per year on the $150,000 I've invested in this airplane over the past 40 years (passion can allow one to look past too much reality).

One concern with a 40-year-old airframe is corrosion. This can be effectively dealt with by good inspections, airframe fogging with ACF50 or CorrosionX and thorough cabin cleanup and zinc chromating during an interior renovation.

A great benefit to ownership of any airplane is belonging to a type club, something that can provide valuable resources and information on many topics.

In summary, here's what I get for $153 per hour: a 180-HP airplane with 120-knot cruise speed with between six and eight hours of range, 60 gallons of usable fuel, 1048-pound useful load and a 13,000-foot service ceiling. It's a safe airplane that's easy to fly and maintain. Thanks to a long list of upgrades and approved modifications, I have enhanced my 172 as requirements changed and finances allowed, making it ideal for my current and long-term needs. This airplane truly does meet my expectations.

Dennis Wolter
Cincinnati, Ohio

FEEDBACK WANTED

PIPER ARROW

For the January 2017 issue of *Aviation Consumer*, our Used Aircraft Guide will be on the Piper Arrow. We want to know what it's like to own these aircraft, how much they cost to operate, maintain and insure and what they're like to fly. If you'd like your airplane to appear in the magazine, send us any photographs (**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. Send correspondence on the Arrow by November 1, 2016, to:

Aviation Consumer
Email at:
ConsumerEditor@hotmail.com