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The Aviation Consumer®

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The Aviation Consumer

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WHAT'S THE BEST DISPLAY UPGRADE?

In an effort to keep the right mix of content, I generally try not to run two major avionics reports in one issue. But this month's *Aviation Consumer* perhaps breaks my cardinal rule twice with reports on not one, but two glass display systems: Garmin's G3X Touch and Aspen's new MAX display upgrade. Unavoidable, really. There's a lot to cover. And in all the years covering avionics for the magazine I'm not sure I've seen this high level of competition. That's not even thinking about ADS-B upgrades, which I'm trying to forget with little success.

While recharging the cameras it occurred to me that in a one-month period the editorial schedule had me flying with three new systems for field reports including the Garmin and Aspen, and Dynon's Certified SkyView HDX retrofitted in a Skyhawk. The photo here is a video B-roll screen grab of it, with my arms crossed watching the Dynon integrated autopilot save the airplane from an unusual attitude.

Wanna know something? After processing the flights with all of these systems, I can't honestly pick a favorite. The significance to that is I couldn't suggest one over another because all of these retrofit systems, in their most tricked-out form, do what most buyers expect them to do. First, they offer relief from vacuum systems. Get rid of it—all of it. If you want to see a thing of beauty, put your saucers behind the panel and in the engine bay of an old airplane that's gone all-electric. No lines, no fittings, no air filters, no deep-chassis space-hogging spinning gyroscopes and no vacuum pump failures. So how might you choose? Look at the installation as a whole, and where you see it in a year or two or three.

Whether or not you want to make the aircraft an all-electric avionics setup should be the first decision you make before even considering which hardware you'll buy. All three systems (there are five, actually, when you count Garmin's TXi and G5 upgrade) are STC'd to replace the vacuum system in its entirety. From a regulatory standpoint it couldn't be easier, which is proof that the FAA recognizes that failed vacuum systems aren't doing the accident stats any favors. And what about displayed data? There's almost too much of it. If you're content with chasing a traditional six-pack of round gauges, you'll likely be overwhelmed—initially, at least—by the data that's presented you on a modern integrated PFD. The smaller the screen area, the more overwhelming it may be.

All of the major glass upgrades (with the exception of Garmin's G5) have synthetic vision so you get a video game-like presentation on the screen when you can't see outside the aircraft. They all display traffic targets, weather graphics, topography, charts and have high-level mapping ability. All (but Aspen) have touchscreen because you've gotten so attached to your smartphone. So the buying decision mostly comes down to how you can adapt to the user interface. And the advice is much like we offer for buying high-end ANR headsets: You have to try before you buy. Period. At the very least, get a hands-on demo in a fully functioning kiosk by a sales rep who knows the product. Observing some at recent trade shows confirms that some manufacturers are losing sales because of poorly executed demos. The best case is to actually fly one, in an environment that best matches your flying. If you fly IFR, how easy is the system to arm and activate an approach procedure (from beginning to end) on the fly?—and that includes setting up the autopilot to fly it. And what about failsafe reversionary? Enough?

Last, if I was upgrading an old panel, high on my list of gotta-have features would be integrated electronic engine data. I'm talking soup-to-nuts replacement of not only engine temperature sensors and display, but also fuel quantity. With the exception of the Garmin G5 and Aspen Evolution system, all of the integrated suites offer the option of replacing all of the original mechanical gauges. Having gotten a taste of the feature in both the Garmin and Dynon retrofit systems, I'm already spoiled. No more bouncing fuel quantity needles, no more having to approximate CHT values and no more gauges spread out all over the panel.

There might not be a slam-dunk best electronic display upgrade, but there are enough worthy choices in a refreshingly competitive market. —*Larry Anglisano*

WHEN A CESSNA 337 IS ALL YOU NEED

I have owned over 30 airplanes and six of them were Cessna 337 Skymasters, so I thought I'd contribute a field report as a follow-up to the coverage in the January 2019 *Aviation Consumer* Used Aircraft Guide.

The six Skymasters I have owned include two 1968 models, a 1975 and 1973 model and currently a 1971 337F model. All were great-running normally-aspirated models, with the exception of the 1969 model, which was a hanger queen. I am a 6-foot-6-inch former NBA player and let me tell you, Cessna is to be commended for thinking of the tall pilots when they designed this tough airplane. I think it's a dream to fly for the owner-pilot who doesn't fly every day for a living.

After leaving pro basketball I became a jazz recording artist, reality-television Dad and motivational speaker. I am based near Nashville, Tennessee, with vacation homes in Destin, Atlanta and Detroit. With my active career schedule and homes in varying states, private aviation is not a want-to but a "have to" activity for me.

As do many pilots, I have a bad habit of reading airplane classified ads and the "grass is greener" bug has bit me several times. I have jumped the fence and owned a Cessna 421, 401, 320, 207, 206, 210, Piper Navajo, Piper Aztec, Piper Cherokee Six and a Beech Queen Air (ouch). But by far the absolute best twin-engine airplane I've owned is the Cessna 337 Skymaster. The best single was a Piper Lance.

I would buy something bigger, then return to the 337. I would buy something faster, then return to the 337. I would buy something prettier, then return to the 337. The 337 always got the job done. Unfortunately some negative comments about the 337 come from pilots who haven't owned the airplane. I can testify my truth on the following Skymaster urban legends:

The rear engine does not overheat—ever, the cabin is not noisy since it sits between two engines, it's not hard to recognize you've lost the rear engine if you're paying attention and last, it's not really a maintenance hog if you keep it well-maintained to start.

Here are some of the major expenses I've seen collectively: You'll want to budget between $2000 and $4000 per year for insurance depending on your experience and the hull value. I paid $1875 in 2019, with 2500 hours total and over 400 in type. If you buy a 337 that has been sitting, you could pay between $7000 and $15,000 for the first annual inspection, and around $5000 for the next ones. It's imperative to bring it to a mechanic who knows the 337 well.

For performance, plan for 160 knots and over five hours of endurance with the 128-gallon fuel tanks. Keep it simple and run it 24-squared on 20 GPH, block-to block. Visibility is great for all passengers, as is the ventilation and heat. Long-legged rear passengers would prefer 1976 and later models because the seat tracks were realigned to allow the passenger bench to roll farther back, giving more legroom.

Rear legroom would be my only complaint with the Skymaster. My 6-foot-tall wife loves the roomy rear cabin in our Piper Lance, which we fly only for day VFR trips. The 337 is reserved for night, IMC and over-the-water trips.

I love the safety aspect of the centerline thrust, although I've never had a real engine failure. But I have been in lots of weather, updrafts, downdrafts and turbulence and the 337 has proven to be a military-grade workhorse.

Ben Tankard
Murfreesboro, Tennessee

PORTABLE HUDS

Nice article in the May 2019 *Aviation Consumer* on the MyGoFlight HUD. But why was there no mention of the Epic Optix Eagle HUD, which at $1844 is a fraction of the cost?

Chris Erkmann
via email

We focused on the MyGoFlight for the flight report because it's a permanent-mount system that is undergoing STC certification. The Eagle HUD from Epic Optix is a portable, non-certified solution. We've flown with the first-gen model and couldn't recommend it because of connectivity issues, something the company said it has worked out with the redesigned unit.

We're planning a report on this current-gen portable HUD (and the Dual Electronics portable XHUD1000—which starts at $500) in a separate article in an upcoming issue of Aviation Consumer.

On The Cover: That's Garmin's certified version of the G3X Touch integrated avionics suite now STC'd for over 500 aircraft models. Editor Larry Anglisano flew with the system in Garmin's Grumman Tiger for a field report, which starts on page 4.

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That's the 10.6-inch landscape PFD and 7-inch MFD, which also serves Garmin's EIS integrated engine display. The system is backstopped by Garmin's G5 EFIS, positioned to the left of the PFD. The suite requires Garmin's digital navigators.

AVIONICS FLIGHT TEST

Garmin G3X Touch: Wide-Reaching STC

Buyers waited years for an STC'd version of Garmin's G3X integrated avionics suite. Now it's approved for 500-plus certified aircraft models.

by Larry Anglisano

During a recent visit to Garmin's flight ops in Olathe, Kansas, I of course respected the request to shut down the cameras in some of the classified work hangars. But let's be clear—Garmin is serious about earning new STCs for a variety of products in an extremely wide variety of aircraft—from pistons to turbines. And that STC list is quickly growing.

Proof is the newly approved G3X Touch installed in a Grumman Tiger that I flew for this report. In case you missed the announcement, the flagship G3X Touch integrated glass panel came from the company's experimental line, but in the course of a year Garmin earned an STC via an approved model list (AML) for over 500 aircraft models. In the current certification climate that's no joke, and neither is the dollar investment to get it done.

With hardware starting at $7995, will the masses line up at dealers for the major install? We think they might, and Garmin banks on it.

BORN FROM THE G300

The current G3X Touch started life around 2008 and ended up in the Cessna Skycatcher as the G300. This was a non-touch, 7-inch portrait display with integrated sensors. The G300 was ultimately redesigned from the ground up in 2011 as the G3X. It was priced less and was easier for amateur builders to install. The system grew, with an updated ADAHRS, and eventually included an integrated autopilot, which ultimately became the GFC500.

Garmin's Team X experimental avionics engineers leveraged some of the technology the company had in the GTN-series touch navigators to ultimately bring to market the G3X Touch. To say the G3X series has been tested in a wide variety of aircraft is an understatement. It's logged plenty of hours—IFR and VFR—in everything from Legend Cubs to L39 jets.

Team X/G3X Touch engineer Joe Gepner learned to fly in both G3X-equipped airplanes and legacy steam-gauge equipped Cessnas and quickly recognized the need for more automation. "With the old round gauges, I felt like I was looking at the world through a straw and ultimately wanted to bring the G3X Touch to certified airplanes," he said. On the other hand, it would seem Garmin didn't have much choice but to earn an STC for the system. After all, Dynon brought a certified version of its SkyView to market, albeit limited to Cessna Skyhawk models. At press time, the G3X Touch has an AML that covers well over 500 models (these are Class I single-engine models weighing less than 6000 pounds), putting enormous pressure on Dynon and its SkyView Certified line. Unlike Dynon, which has opened the installation for its Certified suite to A&P mechanics, the G3X Touch must be installed by Garmin dealerships.

PICK A CONFIGURATION

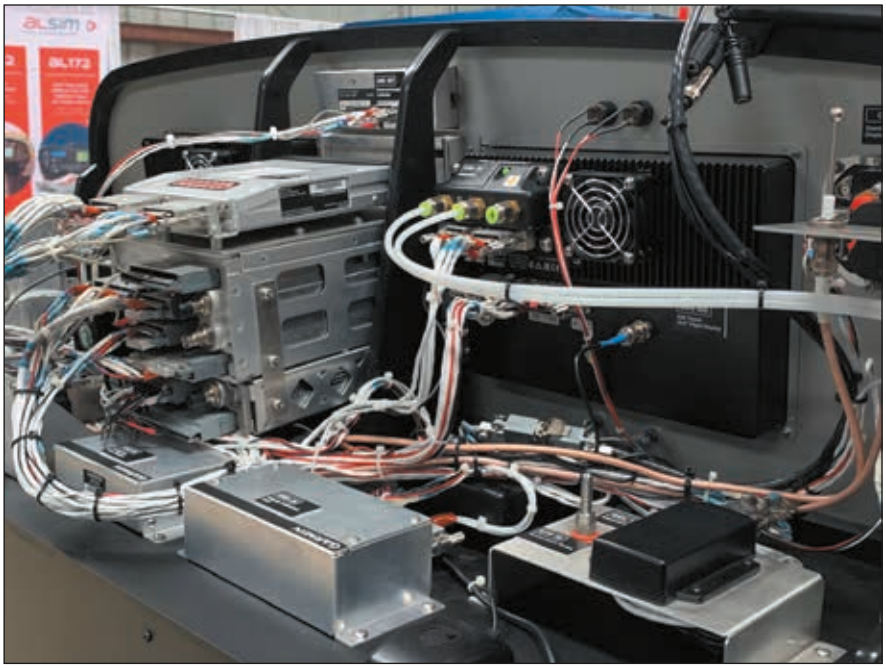
In its most basic form, the certified G3X Touch is configured as a high-resolution 7-inch portrait infrared touch display format. For the $7995 entry price, the system includes Garmin's SVX synthetic vision, plus the built-in Connext wireless technology for transferring flight plans and other data between portables and tablets running Garmin Pilot and ForeFlight tablet/smartphone apps.

The G3X Touch is a complete

CHECKLIST

- ⊕ Garmin offers multiple display options to better suit budget and panel space.
- ⊕ Paired with a second display and a G5 EFIS, there's plenty of failsafe.
- ~ The G3X Touch won't work with third-party analog radios.

Lovers of traditional round gauges will like that the 10.6-inch G3X Touch PFD, top, can be configured as a six-pack instrument configuration—or in a more modern tape format. You can tune the VHF radios and transponder from windows on the top of the PFD. The system connectors and hardware are sturdy and high quality, bottom.



PFD (primary flight display) and MFD (multifunction display) with split-screen capability. It comes standard with Garmin's FliteCharts, SafeTaxi surface diagrams, plus VFR sectional and IFR en route charts.

A step up is the 10.6-inch landscape display, which starts at $9995. There's also the dual 7-inch portrait option, which starts at $12,865. Last is the flagship 10.6-inch and 7-inch portrait display combination—the version we flew with in Garmin's Grumman Tiger you see pictured in this report. It's priced at $14,865.

Buyers will be rewarded with better graphics should they opt for the larger display, or the GDU460. The pixel count for the 10.6-inch display is 1280 by 768, while the specs for the smaller 7-inch display (GDU470) are only 480 by 800.

The main components in a basic suite include the display(s), GSU25D ADAHRS, GMU11 magnetometer and the GTP59 temperature probe. Garmin doesn't charge for the STC and of course provides installation hardware including connector kits for each system. Shops are required to fabricate the harness for each specific install. In other words, they won't get prefabricated wiring bundles or data hubs, and yes, a G3X Touch will be a major installation and transformation that requires sizable panel work. Still, after looking at the hardware it's obvious that shops with experience installing other modern Garmin gear should have no issues wiring up a G3X Touch suite.

The STC includes the green light for removing the aircraft's vacuum system in its entirety. The Grumman we flew had Garmin's G5 EFIS display, which has a battery backup and interfaces fully with the G3X Touch. Spin the knob on the G3X Touch PFD to set the baro, heading, course and other chores and the G5 is synced along so you don't have to set the instruments separately. If the G3X Touch system goes down, the G5 can function as the primary (as can the secondary display, if equipped) and drives the GFC500 autopilot during the failure.

When I flew with the system, demo pilot Jessica Koss pulled the circuit breakers for both displays, which kicked off the autopilot. But with the G5 functioning as the primary data source, we reengaged it and motored along—a non-event.

Speaking of autopilots, the GFC500 autopilot does not come standard in the G3X Touch suite and it is not blanketed in the G3X Touch AML-STC. The GFC500 starts at $6995 and has its own and growing AML. We covered the GFC500 retrofit autopilot for a flight trial in the September 2017 *Aviation Consumer*. It's an impressively tight performer with a long list of standard features, including envelope protection.

Although with far less capability, the system can interface with a variety of third-party autopilots for basic functions, including heading and course command, plus GPS steering.

The G3X Touch will not support the display of flight director command bars, autopilot modes or other annunciation for non-Garmin autopilots.

The G3X Touch at Grumman Tiger rotation speed. The PFD (middle) has integrated angle of attack, SVT synthetic vision, plus engine instruments and fuel data. This optional system is movable from the PFD to the MFD, in various screen configurations. That's split-screen EIS and map, bottom photo.

kits pretty much include everything an installer will need to replace the factory gauges, although there's bound to be the need for some extra install supplies including fuel line and such. Also, be prepared to spend some money either overhauling or replacing aging fuel quantity sensors during the installation. The accuracy of the system greatly depends on the condition of the sensors in the fuel tanks.

Consult with your installer on this because you might be better served by upgrading older analog senders with more modern digital sensors. Garmin told me it tried both (the original and a new CiES digital sender) in the Grumman Tiger installation and found that the digital replacement far outperformed the OEM sender, even after having the old ones overhauled.

Like in the G1000, the EIS in the G3X Touch is integrated into the CAS (crew alerting system) and offers attention-getting and intuitive alerts. I witnessed a real warning when the voltage regulator in the demonstration Grumman failed, allowing the bus voltage to soar off the scale. As you'd expect, the onscreen data for the related flagged system highlights red and an audio alert chime annunciates to get your attention.

I wish the system allowed for the display of wing flaps and landing gear configuration, but it's not included in the STC. Garmin said it could be included in a future revision. There's no angle-of-attack function in the certified system, either, but it exists in the experimental version.

Garmin did a good job of making the EIS display both intuitive and expansive. For instance, the basic engine display is shown in a strip on the left or right side of the display. To access additional information beyond what's displayed on the strip, touch the engine strip and the system jumps to a dedicated engine page where you can see more detail on CHT, EGT, fuel and electrical data. There's also fuel flow calculations if a fuel flow transducer is installed on the engine.

ENGINE DISPLAY

Another major option for the G3X Touch is Garmin's EIS, which stands for engine instrumentation system. It's available for a wide variety of Lycoming and Continental engines and adds $3000 ($3300 for six cylinders) to the price of any suite. The EIS can work with any display, but obviously the larger one is best.

Garmin's EIS is an approved replacement for the aircraft's original engine and fuel quantity instruments and the installation

GARMIN ONLY

Don't plan on interfacing third-party navigators—especially analog VHF nav radios—with the G3X Touch because it's strictly a digital interface intended to work with Garmin navigators. We asked Joe Gepner why.

"In its experimental form, all of the G3X Touch interfaces were (and still are) closed loop, digital and based around Garmin navigators to keep the cost of the system as low as possible," he said. Gepner then pointed to the Garmin TXi series retrofit displays, which are full-up TSO'd systems that do work

G3X TOUCH: FROM RV-7A TO TIGER

Just because the majority of the G3X Touch development was already long done in Garmin's RV-7A (and flying in more experimental and LSA models than we can count in one sitting), earning the broad STC wasn't an overnight process. Robert Murray, Garmin's director of aircraft certification, pointed out that in general, Garmin develops new products from scratch and then brings them to the certification process, including TSO and STC. That wasn't the case with the G3X Touch. The G3X Touch AML-STC process as it stands today took every part of a year and was accomplished in the same regulatory environment in which Garmin certifies other products.

With hardware, software and the IO already in place, it wasn't a matter of presenting the identical experimental product to the FAA for approval. "We knew there were things we built into the experimental version of the system that we wouldn't get away with in the Part 23 world," he said. As we heard from other manufacturers, Garmin said the FAA was motivated to bring the features in the experimental product to the Part 23 aircraft, but there was some tweaking required.

Perhaps the biggest challenge Garmin had with its AML-STC is making sure at least one of the display configurations will fit in the panel. As a result, every aircraft on the G3X Touch AML will accommodate at least the 7-inch display, but not all will handle larger displays. One of the many reasons Garmin has huge success in earning STCs is its huge database of aircraft engineering data—which has taken years and years to develop.

As for keeping the certified G3X Touch installation as simple as possible for its dealer network, Garmin credits its experience offering the product to amateur builders.

"Shops that can install a GTN750 navigator should have no problem installing a G3X Touch," Murray said.

with a wide variety of third-party analog (and digital) radios and autopilots. We were told that offering both lines—the TXi and G3X Touch—will offer more choices for a wider variety of interfaces. Worth mentioning is the TXi series also has wide approval for pistons, twins and turbines.

As for compatibility, the G3X Touch works with both new and vintage Garmin units. This includes the GNS530W/430W, the current GTN navigators, the GNS480, GNC300XL/GPS155XL, SL30/SL40 VHF radios, the GTR225 radio and Garmin's new GPS175 and GNX375 GPS navigators. It works with all of Garmin's GTX digital transponders and ADS-B In and Out devices, including the remote GDL50 series.

While the displays have built-in GPS, it's for positional redundancy and not for navigation.

YouTube See a video of the Garmin G3X Touch at http://tinyurl.com/j95ht2a.

The benefit of the digital interface is quickly apparent—from remotely tuning the radios in the stack via the G3X Touch—to the rich autopilot interface (setting altitude and speed select, as one example) between it and the GFC500 autopilot.

AT WHAT COST?

It's tough to nail out-the-door pricing for a G3X Touch retrofit given the variables that exist from aircraft to aircraft, and the install effort will vary depending on the display option you choose. The 7-inch display configuration might be the easiest, at least from a panel modification standpoint.

The buying decision could get muddy and depending on what you have for existing radios, a side-by-side proposal comparing Garmin's G500 TXi should be in order. As mentioned, that system plays with a variety of third-party equipment, while the G3X Touch is only compatible with digital Garmin gear.

The 7-inch G500 TXi is priced at $11,995, compared to $7995 for the 7-inch G3X Touch. The 10.6-inch G500 TXi is $15,995 compared to the 10.6-inch G3X Touch at $9995. The EIS is optional on all systems.

If you start from scratch, the G3X Touch system you see represented here in the Grumman Tiger is priced at $17,865 with the four-cylinder EIS option. Add the G5 backup EFIS, the GFC500 autopilot, a GTN650 navigator, an ADS-B transponder and an audio panel and the price easily tops $35,000, not counting installation.

Between the G3X Touch and G500/600 TXi suites, Garmin clearly has the market advantage when it comes to integrated retrofit flight decks, and that advantage is heightened by the availability of multiple display options at lower price points and plenty of STCs. Dynon has the SkyView Certified, but it has an extremely limited STC compared to the G3X Touch. We're preparing a comparison report on it for an upcoming issue of *Aviation Consumer*.

GARMIN'S JET RETROFITS: G5000 STC

Garmin's integrated cockpit retrofit program for turbines started with the G1000 for King Airs. That program commenced over ten years ago and according to Garmin's Dave Brown, the company sells as many today as it did early in the project. To date there are over 600 G1000-converted King Airs in the field. It's a complete transformation that now includes Garmin's latest G1000 NXi with the GFC700 integrated autopilot, the latest weather radar, ADS-B and a variety of other functions that modernize even the oldest King Air.

Garmin expanded on the successful King Air program and targeted the Beechjet fleet with the retrofit of its G5000 integrated cockpit. Garmin's latest STC project for jets includes the G5000 retrofit in Cessna Citation XL/XLS models. Like it was in the Beechjet (and the G1000 for King Airs), the G5000 for the Citation is a total transformation that essentially guts the airframe of the existing aging avionics, including the autopilot.

"Basically, you've got a good airframe that operators love, but the thing is these airplanes came out in the mid-1990s and are equipped with older and less capable avionics, to include CRT displays. Now everything has gone to LCD," Brown described. With Garmin's G5000 XL/XLS retrofit operators essentially get all the avionics they would in a brand-new airplane. The G5000 STC program it's currently working on yields the same flight deck that's in a new Citation X, Latitude, Longitude, Sovereign and sister product (the Garmin G3000) in smaller Citation CJ3+ and M2 light jets.

Climbing into the G5000 XLS cockpit it's quickly apparent that Garmin worked hard to improve upon the ergonomics and overall layout of the flight deck. It starts with three 14-inch displays—pilot and copilot PFDs, plus an MFD. The screens (unlike the G1000, these are touchscreen) are so large in the Citation's panel that the corners of the bezels are edged right to the end of the available structure. Lots of screen. The other thing Garmin has done is moved the autopilot control panel to the area previously occupied by the CAS (crew alerting system) just below the glareshield. The old autopilot was down in the center pedestal and not the most convenient location. Most all new jets and turboprops have the autopilot controller at the top of the panel for better ergos. Plus, in the XLS that opens the center pedestal for the two color touchscreen controllers that serve a variety of functions, including data entry for the G5000 suite.

In addition to displaying Garmin's SVT synthetic vision and angle-of-attack data, the G5000 enables a split-screen presentation. That's a big utility in a crewed jet because the pilot can split the center MFD for the data he wants and the copilot can do the same on the other side of the display. A single key on the pilots' touch controller in the pedestal allows each pilot to also split their PFD. Maybe they want engine data (or traffic, weather, terrain) on one side and primary flight data on the other side of the screen.

As you would expect, the G5000 allows for sizable amounts of redundancy and reversionary capability. If you lost any screen, one of the other displays acts as reversionary. Additionally, the G5000 has backup for the touch controllers should they fail. These are mechanical control heads mounted on the instrument that also command the displays. Worth mentioning is the G5000's touch controllers have a feature set and logic that is similar to Garmin's GTN-series navigators, including familiar icons and menu structure. You'll load and activate procedures and build flight plans much like you do in the GTN retrofit navigators.

As modern as the suite is, Garmin is the first to admit that pursuing the G5000 STC won't be worth it for all aging jets. Like any STC, it looks at fleet size and considers the amount of time it will take to earn certification. It certainly doesn't happen overnight. The time-consuming and expensive G5000 STC for the XL/XLS seems worth it given the number of available aircraft. According to Dave Brown, there are over 700 of them in the field.

"This takes years, especially since we're also certifying a new autopilot system along with the rest of the suite," Brown told me. The reason for swapping out the old autopilot isn't necessarily because it's a poor performer. Instead it has more to do with system compatibility. Understand that although the G5000 has an external autopilot controller at the top of the panel, the system is deeply integrated with

the G5000 architecture as a whole. Garmin said there's no easy ability to tie into another manufacturer's autopilot. On a project of this size, this makes sense because you'll ultimately start with a clean slate—essentially zero-timing the entire suite of avionics much like you do with engines.

When deciding which aging jets it will pursue for an STC of this magnitude, Garmin also looks at obsolescence and the overall value of the aircraft. In the case of the G5000 retrofit, owners will be making an investment that's likely north of $600,000 and will require sizable amounts of downtime.

"I think you really look at what you'll have at the end of the project and compare the aircraft to a new one equally equipped, you'll find that you are so many dollars ahead," he said. Brown pointed out that the XLS—with its serviceability, standup cabin, resale value and overall popularity—makes the G5000 STC effort for it a no-brainer.

Of course major avionics work like a G5000 retrofit generally isn't the only upgrade operators may invest in. In the case of the Beechjet market, I've found that owners are making other improvements including upgraded interior, paint and winglets, to name a few.

Brown noted that the STC process for the Citation XLS started nearly two years ago. The aircraft you see pictured here is currently in the flight testing phase, but it's taken huge amounts of effort and engineering just to get there. Installing the hardware in the panel and in the avionics bays is the easy part. It's what goes on behind the scenes that buyers don't realize.

Spend even a short amount of time around Garmin engineers and flight test pilots and you'll quickly hear the phrase HIRF (high intensity radio frequency) and lightning testing. In its engineering lab Garmin has a chamber dedicated to HIRF and lightning analysis.

"We build up an entire harness and connect all of the components in the system, put it into the chamber and then zap it with high levels of RF. If anything leaks into a connector we go back and rework it to make it resistant to RF interference," Brown described. The same can be said for lightning testing. These components have to be able to sustain a lightning strike and huge amounts of testing is conducted before the system is certified.

There's a benefit to having the ability to conduct this high-level testing. A lot of the testing that's done to its higher-end products like the G5000 for jets ultimately trickles down to products for smaller aircraft, including some of the non-TSO products Garmin has earned an STC on. There's also system safety analysis where if a given component fails, what are the other things that will fail down the chain? Once the failure analysis is complete, it's off to the flight test phase where engineers tweak autopilot gains and other airframe-specific parameters. We're talking months, if not longer, to perfect.

At press time, Garmin is within weeks of earning the XLS STC.

—Larry Anglisano

YouTube See a video of the G5000 for jets at http://tinyurl.com/j95ht2a.

Electric Airplanes: Are We There Yet?

Closer, but no cigar. Although certification rules are finally in place (mostly), the economics of e-flight remain murky. Green might not be cheap.

by Paul Bertorelli

In 2014—five years ago almost to the day—Airbus announced that it was bullish on the electric airplane idea and would certify the hybrid four-seater E-fan 4.0 for the U.S. market by 2020. In the meantime, it made a PR splash by flying what would be a two-seat trainer—the E-fan 2.0—across the English Channel.

Two years later, Airbus said, never mind. Not that it's no longer bullish on electric aircraft, but it has moved on to an even more ambitious project in the form of an electric hybrid single-aisle airliner in partnership with Rolls-Royce and Siemens, the dominant force in brushless DC motors used for aircraft.

If anyone in the nascent e-flight business was surprised by this development, they were polite enough not to say so. The real electric airplane market remains a village cottage industry and I learned at Aero in April that the village is very busy indeed. The overarching picture is this: The certification rules are in place, or soon will be, to certify electric aircraft, battery capacity is improving glacially and two companies—Bye Aerospace and Slovenia-based Pipistrel—are set to deliver airplanes in commercial volume. Actually, Pipistrel already has, with about 60 Alpha Electro trainers in the field around the world. But lacking regulatory imprimatur, these have been more technology demonstrators than practical, useful airplanes.

Pipistrel's Ivo Boscarol, left, and Alpha Electro, top photo. "The batteries are still the issue. They are not designed for aviation."

REGS CATCH UP

One effect of having major players like Boeing, Airbus, Siemens and Rolls get into the e-aircraft game is that regulators got busy catching up, at least for light aircraft certification.

"One of the things people have talked about is light sport and in light sport, electric airplanes currently don't fit," says Greg Bowles, who oversees certification issues for the General Aviation Manufacturers Association.

"One of the things we've been doing over the past 10 years is to change Part 23 to performance-based standards that are very prescriptive and detailed. As a result, Part 23 doesn't talk about liquid fuel or electric. The rule is high level and it's very broad. That was the intent," he adds.

Under the Part 23 revision, known as CS23 on the global stage, the regulatory language is broader, with the details filled in by consensus standards developed by ASTM. This follows the method used for the light sport aircraft rule developed by the F37 ATSM committee. The electric standards are coming out of the F44 working group. An early draft of ASTM electric airplane standards has already been approved by the FAA.

"It doesn't encompass everything everyone is going to want to do in electric. Some people want cooling systems, some people want hybrid systems. We're working on those revisions at the moment," Bowles says.

For example, it's likely that early electric cert projects like Bye Aerospace's eFlyer will raise specific issues not addressed thus far. "But what's happened is that the FAA

has been heavily engaged in this, so if someone says, 'hey, I want to do that early,' the FAA has been willing to accept that," Bowles said. He views the consensus standard as a living document that's revised on the fly as needed on about a six-month cycle.

Bowles describes this as more fluid and flexible than past certification oversight and although others I've spoken to in the industry think the consensus standards are pointed in the right direction, there's also a wait-and-see attitude on both the timing and the economics.

BYE AEROSPACE

Not in evidence with a display at Aero, but with an evidently open order book, was Bye Aerospace. The company bagged 60 orders for its under-development eFlyer pure electric trainer. A Norwegian flight academy placed the order, according to George Bye.

Prior to Aero, I visited Bye's Denver headquarters for a look at what will be the eFlyer, the follow-on product to the Sun Flyer airplane the company showed at the major shows for the past couple of years. The eFlyer is a two-place side-by-side combined carbon fiber and fiberglass design powered by a Siemens 90-kw (115-HP) motor with a claimed maximum flight time of three hours.

"For a 2000-pound trainer, it's just the right balance of power, thrust and weight," Bye told me. The eFlyer uses LG Chem lithium batteries with a claimed energy density of 260 Wh/kg, the highest of any of the manufacturers we spoke to. The airplane will have a three-blade composite prop and a Garmin G3X Touch system adapted for electric aircraft use.

When I visited the company, the proof-of-concept airframe had been flown a couple of times. Following the consensus standards GAMA's Bowles described, Bye is aiming for certification and market entry in about two years' time—sometime in 2021.

In the trainer configuration, the eFlyer will have 450 pounds of payload and a speed envelope between 60 and 90 knots, with a dash speed of 135 knots.

"We've got more than enough energy for typical flight training sorties—one hour to 1.3 hours. A quick charge and we're ready to go right into the second sortie," Bye said.

George Bye, right, and eFlyer, lower photo: "We've got more than enough energy for typical flight training sorties—1 to 1.3 hours."

Bye predicts 15 to 20 minutes of charge time and a battery life of 1500 cycles or about 1500 hours, after which the entire pack would be replaced with new cells.

"What's really cool about that is that the batteries are getting better. So the three-hour eFlyer now becomes a four- or five-hour eFlyer," Bye said. But those batteries aren't cheap and neither will the eFlyer be. Projected sticker price is $349,000 equipped as a trainer, but more for private owners who might add options.

The payback is in projected operating costs. The company says the eFlyer will cost $20 an hour in direct operating costs, with most of that—about $8—allocated for battery replacement and the rest for general maintenance and possible upgrades. "Some might call that too conservative. But we want to make sure we have allowances for the unknown," Bye said.

PIPISTREL ELECTRO

Electric airplane ideas come and go at Aero and some are either artist renditions or lab projects one step beyond. One that's neither is Pipistrel's Alpha Electro, the first commercially saleable electric airplane, albeit one that's not certified. Yet. A visit to Pipistrel's booth reminded me of a Tesla dealer.

Pipistrel's Electro is an adaptation of its Rotax-powered Alpha trainer. It uses a homegrown 50-kw-plus (67-HP) motor and a battery array of Pipistrel's own design. The 60 or so Electros in operation around the world face a patchwork of regulation that has made it difficult for the airplane to gain a foothold in the training market.

To address that, Pipistrel's second-generation Electro will be a certified aircraft using similar consensus standards George Bye's eFlyer is following. Some countries already allow electric flight under

With five years in the e-airplane game, Pipistrel has refined its infrastructure to include sophisticated charging stations, right.

ONE YEAR: FOUR ELECTROS

Finding an electric airplane to fly in the U.S. is all but impossible because the only choice—Pipistrel's Alpha Electro—isn't certified and isn't recognized under the light sport rule.

A California group called the Sustainable Aviation Project got around this by flying the Electros under an experimental arrangement. They bought four Electros with a local grant from Fresno County, California, as an advanced transportation demonstration project.

SAP's Joseph Oldham says the four aircraft have been flying for a year and have accumulated some 170 hours in what's largely a demonstration role. Oldham says the group has spent the time testing, validating performance and learning the limitations of electric flight.

The verdict? "The aircraft have quite a lot of capability. Pipistrel designed it as a pattern trainer, but it can actually do more than that if you have the infrastructure set up so that airports are relatively close to each other," Oldham says. That means installing charging stations at more than one site.

The Electro POH recommends that the airplane be flown so as to land with a battery charge of no less than 20 percent. Oldham says that gives the airplane about a 50-mile range. "I now fly them about an hour and still have a good reserve. In the pattern, they're easily an hour or a little more, because you regen on every descent, " Oldham says, referring to Pipistrel's unique propeller that drives the motor and returns power to the batteries.

Oldham says touch and goes aren't recommended because the batteries do better at absorbing the regeneration charge if they aren't immediately asked to deliver takeoff power. The group bought 15-kw chargers for the airplanes, one stationed at each of three airports. Typical charge times from 20 percent are between 90 and 100 minutes, Oldham reports. "You don't have to take them back up to 100 percent, if you just want to do a couple of laps around the pattern," Oldham adds. When we asked Pipistrel's Ivo Boscarol what maintenance the airplane requires, he said none. Has this turned out to be true for the SAP fleet? "They're super reliable. There's just one moving part. There's really nothing to do with the battery packs. You just monitor the system," Oldham told us. He said one motor developed a rough bearing and Pipistrel sent a replacement. "There's no runup, there's no warm up. You just taxi out and take off. It's simple operation. As a trainer, I think it's awesome," Oldham says.

ultralight rules and some are evolving in that direction. Some, says Pipistrel CEO Ivo Boscarol, just close one eye.

"It's nice to be a pioneer, but it's hard to live like this in aviation," he says. The Electro is reliably a one-hour electric airplane, plus reserve. That makes it suitable for pattern training or short forays to the practice area, but not cross-country flying. For interested schools, Pipistrel recommends buying three Electros and one gasoline Alpha for cross-country and other training where the electric airplane lacks endurance.

"The batteries are still the issue. They are not designed for aviation. The cycles are not as we wish because of the very high C Rating we must use," Boscarol adds. (C Rating refers to how fast a battery can discharge for a short, burst time.)

"But if I'm honest, we have sold more aircraft than I expected and now we are receiving four to five orders per month," Boscarol told me.

Because of high battery costs, electrics cost more than gasoline-powered aircraft. The Electro sells for €125,000, plus another €13,000 for the charging system. (That's $139,720 and $14,530 respectively.) The gasoline-powered Alpha sells for €83,100 or $92,869.

As battery capacity remains an issue, so does battery cycle life. As a battery replacement rule of thumb, Boscarol says the cost will be about the same or a little less than overhauling a Rotax engine. So the operational cost delta for the electric is essentially the cost of gasoline and maintenance for the engine. That's not trivial, but with a $61,000 higher price and given the electric's endurance limitations, it's hardly a slam dunk.

Recharge times are between 40 minutes and three hours, depending on the charger system. For its next generation airplane, Pipistrel is considering faster-charging water-cooled batteries. When the Electro was in development, quick-change batteries were considered, but that idea has been shelved.

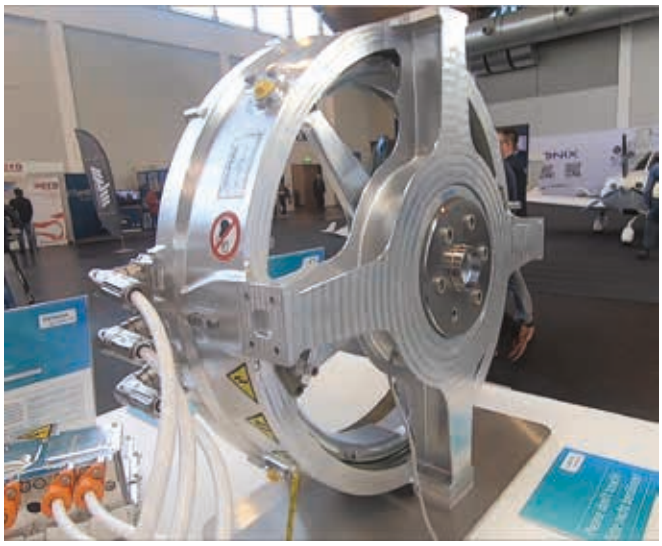
HYBRIDS

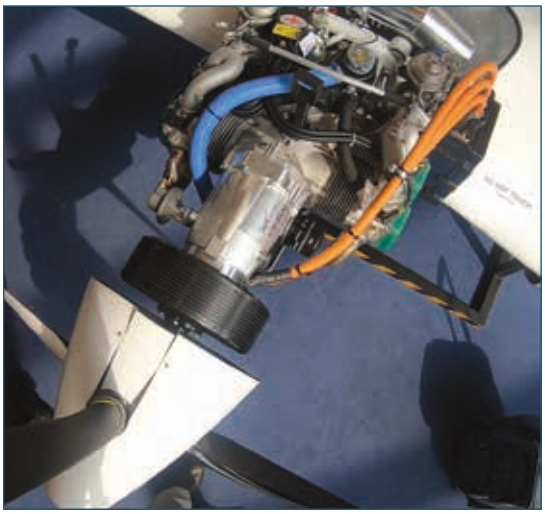
With sales of hybrid electric cars on the rise worldwide—but down in the U.S.—the idea has been migrating to aviation in the form of numerous projects we saw at Aero, some of them aimed at small aircraft, some of them ambitious commercial products that are years away.

By far the most lavishly funded is one called MAHEPA, one of those classic EU acronyms for Modular Approach to Hybrid Electric Propulsion Architecture. Pipistrel's Igor Perkon explained that the idea is to develop common building block solutions for hybrid electric drives and prove the hardware in a way that can be scaled up.

The advent of light, powerful brushless motors has led designers to salivate at the potential of distributed power—placing thrust anywhere on the airframe rather than just as a tractor or pusher. But battery limitations force the reality that realistic continuous power will

The German electrical firm, Siemens, seems to dominate e-flight motors with products like the 350-HP behemoth at right. But there's plenty of competition, too. An Italian company called Alpi showed off a parallel hybrid, lower photo, with a 70-HP electric helper motor attached to a Rotax 912 through a clutch.





have to come from hybrid drives of some kind. MAHEPA follows another project called HYPSTAIR, a hybrid drive system that used a Rotax engine and generator in conjunction with a battery array. Pipistrel led the development on that and although it wasn't intended to fly, it did prove the concept with ground runs.

"We are strong believers in this solution because it scales up easily to higher powers and thus higher takeoff weights using a distributed propulsion approach," Perkon told me. "With the range-extending technology of a generator, plus internal combustion engine or fuel cells … serial hybrid aircraft carry lighter powertrains and most important can perform all-electric taxiing, takeoff and climb, which we see as the typical mission scenario," he adds.

Three other hybrids were shown at Aero, including a parallel drive from an Italian company called Alpi Aviation that places a 70-HP motor in parallel with Rotax engines in a twin through clutch mechanisms, providing for electric taxiing and boosted takeoffs.

Another parallel hybrid is called H3PS and is a joint venture of Tecnam, Siemens and Rotax. The goal is similar to MAHEPA, to produce a flyable, scalable proof of concept. The test article is a P2010 with the 180-HP Lycoming removed and replaced with a Rotax 915 iS. An electric motor in parallel replaces the horsepower shortfall.

Last, a German company called Comco Ikarus was showing a serial hybrid powered by a small two-cylinder engine in the back of the airplane driving an electric motor through a battery array. The company says it's a proof of concept rather than an aspirational product.

WHAT IT ALL MEANS

There's a danger here of getting the cart before the horse and when I asked Nicolas Chabbert of Daher about electrics, he said that's exactly what happened with Airbus. Daher was brought on by Airbus as a developmental partner in 2014 to help with the certification path. "There was a mismatch between what was communicated and the reality of the projects," Chabbert says. "It was way too premature. There was no product there," he adds.

And while he thinks Bye Aerospace is on the right track with its eFlyer, none of the projects in view now are disruptive enough to reshape the market, in Chabbert's view. With almost two decades of electric experimentation, Pipistrel's Ivo Boscarol is similarly cautious.

Yes, the regulations are coming together and yes, batteries are getting better, but the economics of the light trainer market remain an uphill struggle for electric airplanes. Short endurance and charge-time waits are a nuisance, not a feature.

Pipistrel sales exec Michael Coates told me there's a certain novelty factor in buying an electric airplane or putting one on the flight line for training. But that's neither enough to drive a sales boom nor attract—at least thus far—people wishing to learn to fly who might resonate with the green idea of an electric airplane.

Yet Pipistrel has found buyers who might be called the hardcore early adopters. Some are flight schools, some are private owners. "They're usually driving a Tesla or a Prius. They buy the airplane because they feel guilty about damaging the planet and they're willing to put up with the limitations," Coates adds.

He believes the electric market will reach a turning point when endurance is routinely at three hours. That's what George Bye predicts for the eFlyer, but I'd like to see it demonstrated before saying the corner has been turned.

Battery cycle life still remains an unknown. Pipistrel's Ivo Boscarol says the company believes the Electro will need two battery sets or perhaps a little less in the same 2000-hour TBO run for a Rotax gasoline engine. Again, the technology has too little recent history to prove if this is deliverable or if it can be improved. Without that history, Bye Aerospace claims to be there. But it will be another three to five years before we know if that claim is credible.

Aspen's New Pro MAX: Brighter, Faster

Aspen's second-gen plug-and-play Evolution Pro MAX 1000/500 displays get new processors and much improved screen performance.

by Larry Anglisano

Aspen Avionics has enjoyed sizable success with its Evolution series retrofit flight displays for a variety of reasons, including an installation that doesn't require panel modification. The Aspen line also has good compatibility with third-party avionics systems.

But with a production run that spans over 10 years, the Evolution line has needed a boost in modern tech. That's just what the company did with the latest 1000/500 MAX series, fitting faster processors, better screens and a plug-and-play upgrade program that lets existing Evolution owners get in on the new features without buying a complete system. We recently flew with the new MAX displays installed in Aspen's Cirrus and prepared this field report on the new features.

HOW MANY COLORS?

One of the reasons the MAX displays simply look better is there are more colors. Aspen's James Buck pointed out that the older display has six, while the new MAX combines 16 million color combinations. It's readily apparent.

"A MAX upgrade is really a hardware upgrade because the old graphics card, processors and glass just couldn't keep up with what we wanted to do with these displays," Buck said. One thing Aspen did with the new screen and processor was make the displays look more modern. From the second the screen comes alive existing Evolution display owners will notice a huge difference in brightness and clarity.

That also pays back big when the displays are splashed with sunlight. We flew with a three-screen suite (the Evolution MAX 2500) in bright Florida sun. Maneuvering the airplane so the sun was directly blasting the displays, they never washed out and to our eyes looked nearly identical as they did when shaded. We didn't notice any reflectivity, either.

As for specs, the new TFT active matrix LCD displays measure 6 inches diagonally and have a 400 by 760 pixel count. The chassis is the exact same size as the legacy Evolution displays making for a plug-and-play upgrade. If you have multiple screens, all of them must be upgraded to the new MAX for crossfeed. We think it's worth it, especially for the MFD being fed by multiple sensors.

Since the processor is four times faster than the old one, you'll also notice faster map redraws, especially when overloading the display with a lot of data like synthetic vision, weather and traffic. There's no display ratcheting and processing is smooth and fast.

MORE BACKUP AND FAILSAFE

Gone is the bugaboo that Evolution pilots have dealt with for years and it has to do with pitot input failure, including blockage from ice and bugs. Since the Evolution displays use pitot and static pressure input as part of the attitude calculations, loss or corruption of the pitot or static pressure can influence the accuracy of the displayed attitude data, so the data is automatically flagged with the dreaded red X across the screen.

That's not the case with the new

The Evolution Pro MAX 2500 in the main photo consists of the 1000 PFD, 1000 MFD and the 500 MFD. You can buy a single-, dual- or three-screen setup.

CHECKLIST

- Thanks to new display tech, the Pro MAX easily outperforms the older Aspen systems.
- GPS-aided AHRS provides another level of backstop in case of a pitot system failure.
- We wish the new displays had engine data capability and touchscreen.

MAX displays when connected to a compatible IFR GPS navigator, including a Garmin GNS, GTN or Avidyne IFD. The new MAX can use GPS groundspeed instead of indicated airspeed as part of its overall AHRS solution. In that case, the MAX will continue to display attitude and heading data and will display an "attitude degraded" message on the screen to prompt the pilot to turn on the pitot heat. When the system detects the pitot obstruction is clear, the degraded message goes away and the AHRS resets. Aspen users have waited years for this solution and it's built into the new MAX and also the company's lower-end E5 display.

The Cirrus we flew had the three-screen Evolution MAX backed up by an electric attitude indicator, but Aspen told us the AI isn't needed if the MFD1000 in the suite has an external battery pack. With dual ADAHRS redundancy, and the ability to turn the MFD into the primary PFD with a push of a button, this means you can finally ditch all of the existing round gauges.

But not all MAX buyers will opt for the three-screen suite and will go with (or already have) a single-screen setup, which will require a backup attitude indicator. Incidentally, the lower-end E5 display doesn't require a backup attitude indicator as long as it's connected to an IFR GPS navigator. But it doesn't have a TSO and is instead certified via an STC.

NEW USEFUL FEATURES

Users will be pleased that the new Evolution MAX user interface is mostly unchanged from the old system, but Aspen added what we think are useful features. One is the altitude intercept mode.

For example, you're cruising at 2500 feet and you're instructed to climb to 4500 feet. Crank the altitude bug to set in 4500 feet and once you begin the climb, an altitude intercept arc appears on the screen. This simply shows where the aircraft will intercept that selected altitude. The altitude arc will help determine how fast you need to climb to get to the assigned altitude if there are ATC restrictions, as an example.

As simple as it is, our only nit is that the arc might be difficult to see on a busy screen. We flew with the system on a traffic-saturated day and the cluttered MFD was loaded with traffic targets. But there's also useful automation thanks to a new audio panel interface.

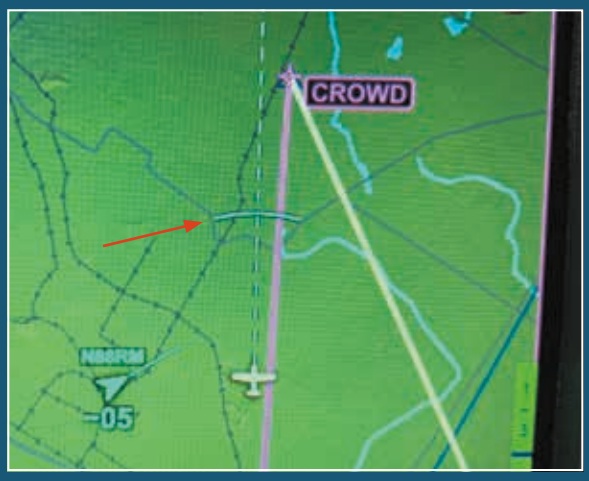
Perhaps the best improvement to the new MAX displays is GPS assist, which uses GPS input when the pitot input is compromised. Those are Garmin GTN navigators middle, but a variety of panel GPS units will work. The MAX in the bottom image is displaying synthetic vision.

When within a couple hundred feet of intercepting the altitude, an "altitude" voice prompt is annunciated in the headset. The system also prompts again when the aircraft has reached the altitude. Deviate from the altitude and the system will let you know with another callout.

Another feature that may seem minimal but is actually useful is the timer utility. Once the aircraft speeds past 35 knots on the takeoff roll the system logs the departure time and stops the timer when you land. You can also set a fuel timer, leg timer and oxygen timers, to name a few more. You don't have to stay on the timer page—the system monitors with audible timer alerts and onscreen annunciation.

Aspen added METAR flags to the second- or third-screen map displays. It's a handy feature that places color-coded METAR flags on the map. Perhaps you're on a long cross-country trip and want to see how the weather is improving or deteriorating. The METAR flags are displayed

MORE ON THE MAX



Counterclockwise from upper right: The red arrow in the image points to the altitude arc on the MAX MFD's map page. It shows where the airplane will be at the existing climb rate. That's a three-screen MAX 2500 suite showing the reversionary PFD on the right MFD1000. It has its own secondary ADAHRS and with an external battery offers the green light for ditching the backup attitude shown on that panel. The last image shows the optional angle of attack display, which doesn't require an AoA probe.

on the dedicated weather page and you can also use the MFD's map panning function and highlight the METAR flag. Aspen said the METAR-on-map feature was one of the most requested features so it added it.

As for map panning, the MAX MFDs (MFD500 and MFD1000) allow for 350-NM zoom levels, while the displays now show height above ground level (AGL) on both the navigation and terrain displays.

Another useful feature that makes good use of the audio output interface is the minimums callout. On the old Evolution system there was a simple minimums bug on the PFD that would flash as you approached the set altitude. On the MAX system the interface is expanded with voice callouts prior to and when approaching the bugged altitude.

MAJOR OPTIONS REMAIN THE SAME

Just like on the legacy Evolution displays, you can add major options to the new Evolution Pro MAX displays. This includes a probe-less angle of attack system, Aspen's synthetic vision and ADS-B weather and traffic overlay capability.

Aspen has made upgrading to the Evolution 1000 MAX as easy as possible, although your current displays will have to go back to Aspen's Albuquerque, New Mexico, factory for the upgrade and as mentioned, all displays must be upgraded in a multi-screen suite. Since the Aspen system uses configuration modules to store installation-specific and configuration data, the upgrade will be a plug-and-play affair.

To take advantage of the MAX system's audio alerting capability, your shop will have to run audio wires from the display to the audio panel.

As for pricing for new installations, a single-screen Evolution Pro 1000 MAX is $9995, the MFD500 MAX MFD is $5495 and an MFD1000 MAX MFD is $8995.

If you already have a legacy Aspen setup, upgrade pricing for a single Pro MAX PFD is $4995, it's $6995 for a two-unit upgrade (a PFD and a MFD) and a three-unit upgrade (PFD and two MFDs) is $7995.

There are a variety of options, but the most popular might be Aspen's synthetic vision for $2995 and the integrated angle of attack unlock kit for the PFD and MFD at $2790.

There's also an optional software unlock kit, which Aspen calls the Evolution Hazard Awareness. You'll need it for displaying traffic and weather and it costs $895.

If you already have these features on your current Aspen display, you won't have to pay for them again when you upgrade the displays to the new MAX. These are retained in the configuration module. The upgraded MAX displays comes with a fresh two-year warranty.

While we wish the Aspen MAX had the ability to display engine data, and perhaps had a touch-screen interface, the MAX upgrade offers a sizable boost in performance for buyers who have already spent big for capable but aging legacy Evolution systems.

Visit www.aspenavionics.com.

YouTube See a video of the Aspen MAX system at http://tinyurl.com/j95ht2a.

PILOT ACCESSORIES

JupiterBike V2.0: Electric Tech, Compact

The JupiterBike V2.0 is small enough to stash in small baggage areas and has a lightweight frame. The Discovery is larger and heavier, but folds.

by Phil Lightstone

For me, a good alternative to securing an FBO crew car is bringing my own foldable bicycle. That's why I was interested to try two new models from Jupiter Bike, which is part of Tampa, Florida-based Daniels Technologies. The company was showing off the goods at this year's Sun 'n Fun fly-in.

The two bikes are much different from each other. The JupiterBike Version 2 does not have pedals, uses electric braking and is smaller and lighter than the Discovery bike. The Discovery has greater all-electric range, but with pedals can be ridden when the battery is depleted or for those looking for exercise. Here's an overview.

SIZE MATTERS, PARTLY

Foldable bikes have been around for decades and my first one was made by Fuji, weighed 45 pounds, and with full-size 26-inch wheels, it awkwardly hinged around the aircraft seat post. It fits easily into the trunk of a car, but required some serious effort to get it into the back of a Cessna 182.

Plus, I was always concerned about getting grease from the chain on the seat fabric, and I used the passenger seatbelts to strap the bike in, making it safe for flight. The usual bike ride into town from the airport was a distance of about 6.5 miles. Since I'm not overly athletic, it was a bit of a workout. Enter e-bikes.

Polymer lithium ion battery technology has changed the off-airport transportation capabilities. The evolution saw small-framed folding bikes designed with small wheels, electric-assisted pedal bikes and all-electric bikes with pedals. With technology concepts taken from the automotive industry, lightweight all-electric bikes are able to perform with surprising speed and agility.

JUPITERBIKE V2.0

Yes, the latest JupiterBike electric model is small enough to stash in a backpack. This bike is designed with lithium ion batteries in the front wheel and an electric motor in the rear wheel. With 10-inch wheels, a high-capacity battery and a powerful brushless electric motor, speeds of up to 15 MPH are attainable, with a duration of 10 miles—which might not always be long enough.

Thanks to the aluminum alloy frame, the bike weighs in at around 32 pounds. Acceleration is brisk and the bike has good brakes, assisted by the electric motor. There are no brake calipers or other hand brakes. Two electronic switches built into the handles are used for acceleration and braking. The right-hand switch is the accelerator and the left-hand switch is the brake.

JupiterBike's folding design is unique, with a hinge in the middle of the frame. The wheels unlock and fold inside of the frame, making the bike exceptionally small. It's sized at 16.3 by 20.5 by 5.75 inches when folded, and 49 by 6.29 by 35.5 inches when unfolded. It's nearly the perfect size for stashing in a baggage area.

As for performance, since it has a 39-inch wheelbase it's stable in turns. Heavy riders make note: The aluminum alloy makes the bicycle light, but limits the maximum rider weight to under 220 pounds.

But thanks to ample seat adjust-

CHECKLIST

- The V2.0 model is easy to fold and stow, plus it's a good performer.
- The larger Discovery is fully electric or has pedal assist. It also has good brakes.
- Might not be street legal in all areas you fly to. At $1595, the Discovery is premium priced.

That's the JupiterBike V2.0 in the lead photo. It has 10-inch tires, a lightweight frame (total bike weight is 32 pounds) and is priced at $895.

The JupiterBike V2.0, top, is fairly minimal, but that is what makes it easy to load and stow in the airplane—or a backpack.

ments, the frame accommodates a good range of body heights. For more comfort, the seat can be upgraded—something company President Rob Daniels said most buyers do.

The 13S lithium ion battery, built into the front wheel, delivers 10.3 Wh per cell for a total of 135 Wh. Jupiter Bike offers a replacement front wheel assembly when the supplied batteries reach the end of life. Instead of replacing the battery, just swap the wheel out.

Replacing the front tire requires some effort using a hex wrench, X-Acto knife and pliers. A video that shows the process is at https://tinyurl.com/y2uubhcb.

For charging the batteries there's a small charging port (and a lighted On/Off switch) on the side of the front frame. The included 100-230 (VAC) AC/DC charger will automatically shut off when the battery becomes fully charged in two hours. You can purchase additional chargers, but be sure to top off the batteries before you go—charging li-ions while airborne is not recommended for obvious reasons.

The JupiterBike V2.0 is priced at $895, includes free shipping within the U.S. and has a one-year warranty, which excludes tire wear. The bike is available in various colors: black (the most popular), orange, green, white and light blue. The trendy orange paint seems best for higher visibility.

AN APP AND ACCESSORIES

The bicycle works with an app (compatible with Android and Apple smartphones) and the company sells a bracket to hold the phone on the handlebars. The app connects to the bike via Bluetooth and displays a speedometer, battery level, a compass and support information. A speed limiter can be programmed through the app, which might be wise for kids and blue-haired pilots.

A variety of upgrades and accessories are available, which quickly grow the price. There's a rolling backpack ($89.95), dual spring leather seat with LED taillight ($44.95), universal cross grip smartphone mount ($24.95), LED front light ($44.95) and the Accessory Pack. It includes a backpack, leather seat, front LED light and a smartphone mount ($179.95). The seat upgrade, which has dual springs, is much wider and softer than the

continued on page 20

ROLL YOUR OWN BIKE RACKS

That's if you fly an experimental aircraft, which is just what I did for my kit-built Dream Tundra pictured here.

While folding bikes or powered scooters seem to be the normal way of carrying transportation in your personal aircraft, there are other options—especially when you fly a big hulking experimental bush plane that regulations allow you to modify. And if you like to fly that bush plane out into the back country and you want surface transportation when you get there, external bike racks are one answer. This does, however, elicit comments and stares from just about everyone when you pull back up to a fuel pump at a civilized airport. "You really fly with those things on there?" is the most common question, which I find odd, since most of the time, we just landed, so the answer should be obvious.

We didn't invent the idea of carrying external loads—thank our friends in Alaska and Canada for that—and we didn't even invent the bike racks that we have on our kit-built Dream Tundra. We got the idea (and a set of plans to help us get started) from the folks at Murphy Aircraft, a Canadian kit company that decided their new Radical aircraft model wasn't quite far out enough, so they hung mountain bikes on the wings and took it to shows. After flying the Radical myself—with bikes hanging out there—I figured it would be a great way for us to haul our own surface transport out into the wilds of our Nevada home.

Starting with a set of plans provided by Murphy, I quickly delved into a few changes due to the availability of materials and tooling. The backbone turned out to be easy to make from a square aluminum tube cut in half lengthwise. The mounting points pick up reinforced areas on the main and rear spars of the wing, just outboard of the strut attachment points. The vertical posts are streamlined aluminum tubing, and the cradle that hugs the bike's diagonal tube is formed from 4130 steel sheet. The weight of the bike is actually taken by this post and the tires are strapped in to the backbone for stability.

Construction was simple for a multiple-time homebuilder who has a shop full of tools and there was nothing out of the ordinary for fabrication. Of course, we built one for each side to keep things symmetrical, and my wife has the same bike as I do, so weight and (lateral) balance worked out just fine.

Flying with the bikes installed lowers the normally sedate cruise speed from about 115 knots down to 105—there is no getting past the fact that bicycles are draggy. After putting the airplane back in to Phase 1 testing (required for modifications that might change handling characteristics), we flew a full set of stalls with one bike and two, as well as with bare racks. We flew the full range of airspeeds up to redline as well, and noticed no real difference in handling or performance. This is probably a testament to the Tundra being fairly draggy to begin with. I half-expected the airplane to fly like a twin with an engine out with only one bike, but it was, in fact, very well behaved, and there was very little yaw from this configuration.

Hanging your bike outside might seem like a pretty foreign concept, and of course, it is going to take away considerable performance from any kind of fast-moving airplane. But, these rarely have high wings anyway, so racks aren't an option. But for flying over the nearest mountain and landing on a lakebed in the middle of Nevada, the external bike racks are convenient, and get you where you're going with REAL mountain bikes capable of handling the back country. For this specialized case, the racks make a lot of sense—even if they do still get a lot of strange looks.

—Paul Dye

That's the Jupiter Discovery, opened and folded, in both images above. It weighs just over 42 pounds with the frame-mounted battery.

standard seat and is well worth the money, in my view.

A variety of spare parts may be purchased. These include foot rests ($19.95), spare charger ($13.95), front wheel with batteries ($119.95), rear wheel with motor ($119.95), tire tread ($28.95), seat adapter kit with quick release ($15.95) and a standard snap-on seat ($14.95).

It was natural for Jupiter's Rob Daniels to begin work on the next model. Version 3.0 of JupiterBike will essentially be the Version 2.0 model, but inclusive of all the accessories offered on the website; think of it as a fully loaded model. I'm told that the aluminum frame has been re-engineered to support more weight, or heavier people (only one rider per bike—the handlebars will not support the weight of an additional rider). With Version 3.0 of the bike still under development, few specific details were available at press time.

USING IT

The performance of this compact e-bike is impressive. Test riding the JupiterBike V2.0, I found it to be quite peppy and nimble in the turns. Acceleration was surprisingly quick. The accelerator switch is built into the right handle, while the brake switch is on the left handle. For me, it seemed quite natural, much like a car. The braking of the electric motor delivers rapid deceleration of the bike. Simply releasing the accelerator switch causes the bike to slow down and coast. The brake switch, on the other hand, is for stopping RIGHT NOW, bringing the bike to a stop quite quickly. While I did not try pressing both switches at the same time (braking and accelerating), I expect that you could create some interesting tread marks at the airport.

Folding and unfolding the JupiterBike V2.0 is not complicated. It uses four spring-loaded adjustable cam locks on the wheels and handlebars. The seat uses a friction lock to adjust its height. Finally, a latch on the frame's hinge locks the frame together.

Unfolding the bike—with a bit of practice—takes about two minutes. It's worth watching the training video on Jupiter Bike's website; it walks you through the process step by step. In the short video you can see a professional fold and unfold the bike. In fact, there are a number of videos on the website providing step-by-step instructions for various maintenance items, including replacing the front tire when the batteries need to be replaced.

And of course the usual caveats apply: Wear a helmet and other smart riding gear. Last, before loading the bike in the airplane for traveling, check the municipal regulations for the operation of electric bicycles. In Ontario, Canada, for example (where I often operate) for the e-bike to comply with the Highway Traffic Act it must not weigh more than 120 kg, electrical terminals must be completely covered, the bike must have two independent braking systems, a minimum wheel width or diameter cannot be less than 35 mm/350 mm, it cannot exceed a power output of 500 watts or a speed of 32 km/h and it must have pedals.

JUPITER DISCOVERY

The $1595 Discovery model is a heavier and larger e-bicycle, weighing 42.25 pounds with the battery. With 16-inch inflatable tires, a high-capacity battery and a powerful brushless electric motor, the Discovery turns out speeds of up to 16 MPH, with a duration of 40 miles per charge.

The bike is built around a magnesium alloy frame (it also has a kickstand), which helps keep the weight of the bike down, compared to other traditional bikes. Braking is

CONTACT

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813-609-2453
www.jupiterbike.com

That's the Discovery's handlebar-mounted display, top, and the rear wheel/brake/kickstand setup, bottom.

accomplished by front and rear disc brakes and I found them to be quite effective.

The bike's folding design has a hinge in the middle of the frame. The Discovery folds in half and has foldable pedals and a removable seat, making the bike compact for its overall size. It measures 30.08 by 25.08 by 16.93 inches when folded, and 52.75 by 34.3 by 21.65 inches when unfolded. The wheelbase is 37.4 inches and it's stable in turns.

The maximum weight of the rider cannot be more than 265 pounds, which is more than the JupiterBike V2.0 can handle. And like the V2.0, the Discovery's adjustable seat provides ample height adjustment for a wide range of body heights.

BUILT-IN ELECTRONICS, VARIABLE SPEED

Unlike the app-controlled JupiterBike V2.0, the Discovery has a built-in LCD screen and a three-button user input. The display shows battery life, speed and diagnostic icons. The battery slides into the side of the frame and is accessible when the bike is unfolded.

The Discovery has a built-in front headlight that is controlled by one of the buttons on the display, while the electric motor is controlled by the "M" button on the screen. Pressing this button switches the motor on and off, in addition to changing the bike's speed: There's 0, which is pure pedal-power riding with no electric power; 1, which is a low-speed mode (maximum of approximately 8 MPH); 2, which is mid-speed mode (maximum of approximately 11 MPH); 3, which is the high-speed mode of 16 MPH.

The lithium ion DC battery, built into the frame, is a 36-volt, 5.2-Ah battery for powering the 250-watt electric motor. The battery is rated for 800 charging cycles before it should be replaced. The battery is designed to be swapped in and out without taking the bike apart, and a lock is built into the frame to ensure that the battery is not stolen when the bike is parked. Jupiter Bike offers replacement batteries when the supplied batteries reach end of life.

A small charging port and lighted On/Off switch is on the side of the front frame. The included 100-230 (VAC) AC/DC charger will automatically shut off when the battery becomes fully charged in four hours, but should not be charged for longer than six hours.

The Discovery's spare parts include a spare battery pack ($250), disc brake ($35) and tires ($35 each).

BUY DIRECT OR AT AMAZON

Jupiter sells its e-bikes direct via its webpage (www.jupiterbike.com) or look for them on Amazon. There's even a 24-month payment plan. With interest the JupiterBike V2.0 is $47 and the Discovery is $84.

I test rode both the JupiterBike V2.0 and the Discovery bike and found them both to be agile and easy to ride. I also like the idea of having pedals to give me some well-needed exercise, while never worrying about a dead battery. With that said, the lightweight frame on the JupiterBike V2.0 is attractive. I'm hoping that in the near future, more states and provinces will allow pedal-less e-bikes on the roads. After riding both, it's easy to see they are different, which could help the buying decision.

For those who use a bike infrequently and are just looking for improved mobility to and from the airport (less than 10 miles), I think the JupiterBike V2.0 hits all the marks, especially for portability.

It's priced fairly at $895 and is a worthy option for sightseeing or getting into town when the FBO crew car is otherwise occupied.

uAvionix skyBeacon: One User's Experience

Installation of the uAvionix skyBeacon was fast and straightforward. Meeting the FAA-defined rebate performance standards was another matter.

by Rick Durden

In the last month I had a wingtip-mount uAvionix skyBeacon ADS-B Out universal access transmitter (UAT) installed on my family's 1966 Cessna 182. On the subsequent flight to show that it met the performance requirements for the FAA's ADS-B Out rebate program, it failed. That begat a frustrating process to figure out what was wrong and rectify it.

I'll put the conclusion up front: There was nothing wrong with the skyBeacon and my shop installed it correctly. The problem proved to be a combination of living in an area of fringe ADS-B and radar coverage and how the FAA interprets ADS-B Out performance data.

I live about as far north in Idaho as you can without saying "eh!" Northern Air, the FBO on the Boundary County Airport (65S), ordered the skyBeacon and lead maintenance technician Phillip Heisey installed it. Total time for the install was a wallet-pleasing, short 2.5 hours.

That's it, unless you want the FAA rebate. Then, assuming you already registered for the rebate program—you do that prior to the installation—you have to make a 30-minute flight in "Rule" airspace where ADS-B Out will be required next year and obtain a report from the FAA confirming that your system meets FAA-defined performance specs.

THINGS GET WEIRD

That's where things got weird.

For solid radar and ADS-B coverage, I flew to Spokane, Washington, and remained in its Class C airspace for over 30 minutes and returned.

I landed and requested the performance report. It showed a 45.82 percent Mode 3A failure. Bottom line, the system didn't meet the FAA's performance requirement.

The material my shop had on the skyBeacon pointed potentially at a "Transponder Monitor Threshold" issue and directed us to a uAvionix video. Not wanting to make an adjustment to the system, hoping it would work, and then, potentially, make several not so cheap test flights before getting it right, I sent uAvionix an email describing the problem and attaching the performance report. Within two hours I was called by David Wagner, who had reviewed the report. In a wide-ranging conversation his bottom line was that the unit was fine, I just happened to live somewhere so far from good radar and ADS-B coverage that the percentage of my flight outside of coverage would generate a failure under the FAA's algorithm.

Wagner suggested that I fly to Class C airspace, land, wait 15 minutes and then take off and fly within Class C for 30 minutes and land again. That way there would be no issue with the FAA's metrics.

I then sent my report to the FAA and requested a manual data review. The response was a terse assertion that my system had failed—the FAA's conclusion stood. I shared this with uAvionix and we concluded that I had to make multiple flights to confirm compliance.

I flew to Spokane International, landed, taxied in, paid the $40 ramp fee and waited 15 minutes.

Back at the airplane I talked with clearance delivery and explained that I wanted to fly in the Class C for 30 minutes and land again. The flight proved routine and dealing with the pros at Spokane ATC was a pleasure.

After landing, I got on my computer and requested the FAA performance report. It generated good news: The uAvionix skyBeacon had met all the required parameters.

Total cost to comply with the rebate requirement: an unpaid day off of work, numerous emails and phone calls, 4.5 hours flying at $125 per hour plus $40 ramp fee. I'll get a $500 rebate. Oh, well.

Takeaway: If you have to fly any distance to be assured of ADS-B and radar coverage in Rule airspace, you might want to forego seeking the $500 rebate.

The FAA-generated track of the author's first ADS-B Out flight in Spokane Class C airspace attempting to show the system complied with FAA performance requirements.

Diamond's DA50, Flight Design F2, F4

Diamond resurrected DA50 development with a Continental CD-300 diesel while Flight Design rolls out a modular approach to new singles.

by Paul Bertorelli

For at least the past five years, the spring product rollout season has shifted eastward away from Sun 'n Fun and toward Aero Friedrichshafen. And so it was this year, with two major developments from Diamond and Flight Design.

Diamond's unveiling was actually a reheat of sorts. It appears to be going after Cirrus with the revived large-cabin DA50 single, this time powered by Continental's recently certified CD-300 six-cylinder diesel. The DA50—at least the airframe—isn't exactly new, having first appeared at Aero in 2006 as a skunk works project of then-Diamond owner Christian Dries. It simmered along until Diamond encountered trouble with the DA42's diesel engines, followed by the severe economic downturn of 2008.

When the airframe reappeared, it had another engine and had morphed into the million-dollar-plus DA62 twin, which has proven to be a moderately strong seller for Diamond. As a single, the DA50 fuselage is of similar size and will accommodate at least five seats, with a wide bench in the back. Will Diamond try for a sixth? We don't know.

Continental's CD-300 300-HP turbodiesel, certified in 2017, is based on a six-cylinder Mercedes auto diesel with four valves per cylinder, electronic common-rail injection and turbocharging on a weight of 548 pounds. Initial time between replacement—no overhauls at first, evidently—will be 1200 hours. No performance was given, but the airplane represents one interesting departure from what has become a modern design standard: It's a retractable. Our guess is 200-knots plus at altitude.

Recall that German-based Flight Design had its own four-place airplane, the C4, in the works until it ran into financial trouble. At Aero, the reorganized company announced a rethink of the CTLS line and a new four-place project called the F4. The latter will be a CS 23-certified aircraft that's essentially a stretched version of the CTLS. Predictably, the powerplant will be Rotax's new 915 iS. Gross weight is set at 2420 pounds with performance in the 150- to 160-knot range. The price target is under $300,000.

The CTLS line will endure, says Flight Design, but include the F2, which the company has dubbed MACCS for modular airplane construction and certification system. That means one base model can accommodate several equipment levels and powerplants, including an electric model if market demand warrants.

The F4 is planned for certification in about a year's time. Meanwhile, the C4 hasn't been abandoned, but it's not a front burner project, says Flight Design.

Continental CD-300, top, will power the revived DA50, center photo. The Flight Design F4, bottom photo, is recognizable for its stretched nose and cowl scoop.

Piper Warrior

It's no speed demon, but Piper's familiar Warrior is simple, efficient and has no bad habits.

For a history lesson on the eventual success of Piper's Warrior, look back to the alluring post-World War II boom, where major airplane manufacturers, to include Aeronca, Luscombe, ERCO, Piper and Cessna, among others, all eventually came to the conclusion that the future for mass-marketing airplanes was wrapped up in something that had four seats and on the order of 150 HP. Some manufacturers gave up after limited success, while Cessna and Piper went on to fight it out for decades, as Beech and Grumman-American tried to make inroads.

That four-seat, 150-HP niche proved to be the beginning rung of a market ladder where airplanes can excel as trainers, but can also be practical traveling tools. As a Warrior proves, the tradeoff is they won't haul a lot of people or cargo, nor will they do it quickly, but they offer economical travel. They often serve as a pilot's first "real" airplane after primary training. The market demands that they be reliable, inexpensive to operate and relatively easy to fly. They must excel as rental airplanes—thus be designed to be flown by any pilot, and withstand the consequent beating, while providing a reasonable income to the FBO.

Burning 7.5 to 10 GPH at cruise, these birds yield a fairly good range with four to six hours of flying.

Against the Cessna Skyhawk, the Piper PA-28-151 or -161 Warrior came a respectable second in the race. It, and the AGAC AA-5 Traveler/Cheetah, are good, solid airplanes that can be had for budget dollars. But it wasn't an easy climb.

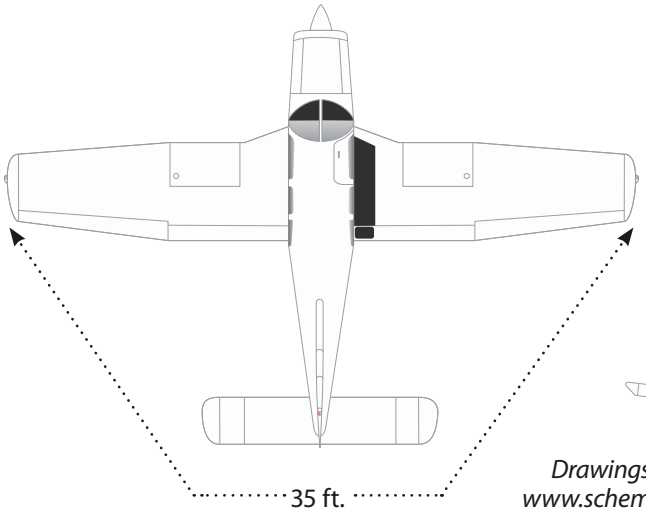
The AA-5 went the way of the dodo in the late 1970s, and attempts to resurrect it (in the form of the Tiger) failed. Beginning in the mid-1980s, Piper, too, fell on hard times and was forced into bankruptcy, finally emerging several years (and a few abortive buyout attempts) later as The New Piper, although "new" was dropped from the company's name.

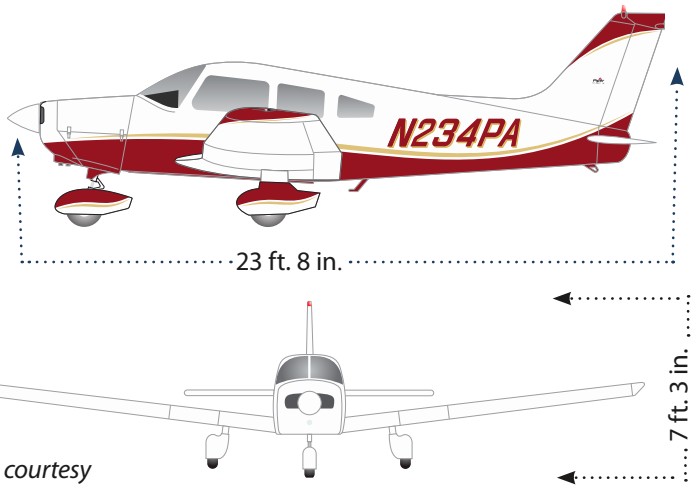
Today, all seems quite good at Piper. This past spring it even introduced the new $259,000 Pilot 100 model aimed at smaller flight schools.

Unlike the Skyhawk, and with only one or two exceptions, the Warrior has been in production throughout, even if the number of airframes manufactured in its last several model years could be counted on one hand. In the "Warrior III" configuration, the model was marketed mainly as a trainer before quietly disappearing from Piper's

In 1980, a new Piper PA28-161 Warrior II like the one pictured in the lead photo sold for $39,070 when equipped with options. The last Warrior III sold for $289,900 in 2016.

PIPER WARRIOR



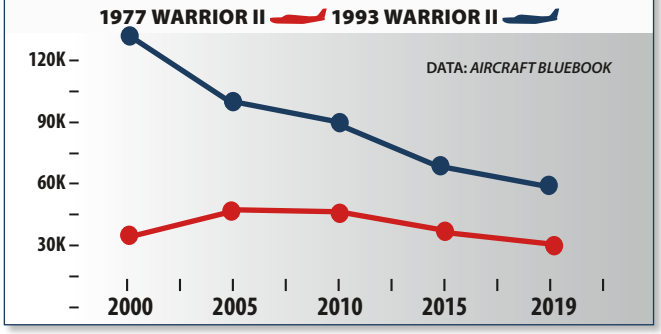


Drawings courtesy
www.schemedesigners.com

PIPER WARRIOR SELECT MODEL HISTORY

MODEL YEAR	ENGINE	TBO	OVERHAUL	FUEL	USEFUL LOAD	CRUISE	RETAIL
1974 PA-28-151 WARRIOR	LYCOMING O-320-E3D	2000	$20,000	48	989 LBS	110 KTS	±$27,000
1977 PA-28-151 WARRIOR	LYCOMING O-320-E3D	2000	$20,000	48	989 LBS	110 KTS	±$30,000
1977 PA-28-161 WARRIOR II	LYCOMING O-320-D3G	2000	$20,000	48	981 LBS	118 KTS	±$27,000
1983 PA-28-161 WARRIOR II	LYCOMING O-320-D3G	2000	$20,000	48	1096 LBS	118 KTS	±$33,000
1988 PA-28-161 CADET (VFR)	LYCOMING O-320-D3G	2000	$20,000	48	1096 LBS	118 KTS	±$18,000
1997 PA-28-161 WARRIOR III	LYCOMING O-320-D3G	2000	$20,000	48	1096 LBS	118 KTS	± $64,000
2000 PA-28-161 WARRIOR III	LYCOMING O-320-D3G	2000	$20,000	48	1096 LBS	118 KTS	±$75,000
2005 PA-28-161 WARRIOR III	LYCOMING O-320-D3G	2000	$20,000	48	1096 LBS	118 KTS	±$105,000
2013-2016 PA-28-161 WARRIOR III	LYCOMING O-320-D3G	2000	$20,000	48	1096 LBS	118 KTS	±$255,000

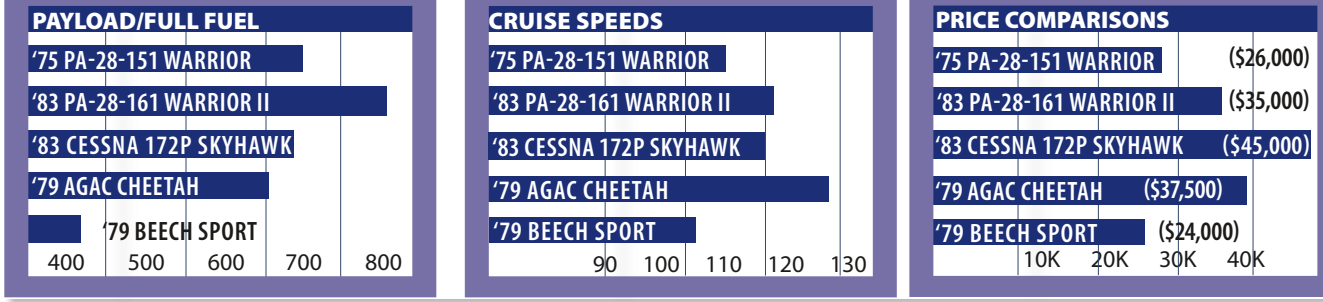
RESALE VALUES



SELECT RECENT ADs

AD 2013-02-13	INSPECT STABILATOR CONTROL SYSTEM COMPONENTS
AD 2010-15-10	INSPECT/REPLACE CONTROL WHEEL SHAFTS
AD 98-01-06	INSPECT/REPLACE PRECISION AIRMOTIVE CORP. CARBURETORS
AD 96-10-03	INSPECT/MODIFY THE FLAP LEVER ASSEMBLY
AD 95-26-13	REPETITIVELY INSPECT OIL COOLER HOSES TO PREVENT FAILURE/RUPTURE

SELECT MODEL COMPARISONS



Avidyne's Entegra, top, was offered for several years and included Garmin GNS430s. But the majority of used Warriors you'll find for sale sport steam gauges and in some cases, KX170Bs from the days that King was the king of the avionics world, bottom.

lineup a few years ago, even if many have been a flight school favorite since its inception. Equipped with a Garmin G500, plus a GTN650 touchscreen avionics suite, ADS-B system and other modern electronics, the newest (2016) Warrior has an average retail price of $260,000, according to Aircraft Bluebook.

A glance at current prices of mid-1980s Skyhawks and Warriors shows that PA-28-151/161 prices have closed some of the historical gap with the Skyhawk, but are still a relative bargain: The 1984 Cessna 172P II averages $10,000 more than a 1984 Piper Warrior (which averages $35,000 retail), according to the *Aircraft Bluebook*.

HISTORY/PERFORMANCE

As general aviation was entering its heyday of the 1970s, Piper's line was beginning to look dated. The basic PA-28 had come out in 1962, and hadn't changed all that much. Piper's PA-28 and -32 singles all had the characteristic, constant-chord "Hershey bar" wing, and the company was about to lower the boom on the sleek Comanche. It was time to update the line.

A new airplane was planned, one that would take aim squarely at the Skyhawk. Previously, Piper didn't really have a strong competitor for the Cessna 172, even though it offered Cherokees with 150 or 160 horses through most of the 1960s. The Cherokee 140 was more cramped, being more of a 2+2 airplane than a true four-place, and it didn't perform as well as the Skyhawk.

The first Warrior was introduced in 1974, powered by a 150-HP Lycoming O-320-E3D engine. It didn't replace the Cherokee 140, though the 140 did succumb to poor sales after the 1977 model year.

The Warrior boasted one big difference: a new, longer, semi-tapered wing with a higher aspect ratio. This new wing helped the handling, with lighter roll control forces, and also boosted the climb rate. It also helped the airplane's looks. The new wing design first appeared on the Warrior, but eventually found its way into all of the PA-28 series as well as onto the PA-32.

Interestingly, the new design represented a deviation from the production efficiencies originally touted as a virtue of the constant-chord wing. And it's fun to recall some Piper engineers, back when it was introduced, boasting that the fat, new, stubby wing was actually every bit as good as the sexier-looking tapered Comanche wing, aerodynamically. Piper's most significant upgrade to the Warrior came in 1977 when a slightly different O-320 engine—the -D3G—was bolted on, offering a 10-HP boost in output. The results were dubbed "Warrior II."

A couple of other evolutionary changes occurred in 1978, when Warriors received more streamlined wheel fairings, and in 1983, when the battery was removed from under the rear seat and placed in front of the firewall. The new fairings—aftermarket versions of which are available under STC—yielded some 7 knots in cruise speed, according to the book (optimistic numbers, users tell us), while the battery change shortened the run to the starter and helped combat starting problems (though these had been largely overcome, according to users, by swapping copper for aluminum cables).

Thanks to the change in weight and balance, shifting the battery location allowed the gross weight and useful load to be hiked by 115

A Warrior's systems don't get simpler. The split cowling makes preflighting the Lycoming engine easy, top. The fuel system and flaps are simple, too. Draw fuel from the left or right tank, and pull the big handle to deploy the wing flaps, bottom photos.

pounds, and extended the aft CG to allow more of a load in the baggage compartment. (The boost is available via STC for older Warriors.)

An attempt to create some interest in a moribund new-airplane market was made in 1988, when Piper released a version of the Warrior, targeting flight schools, called the Cadet. A stripped-down Warrior, it was available in VFR and IFR versions. The experiment continued through the 1994 model year. Another spruce-up resulted in the Warrior III in 1995, which remained in production through 2012.

Today, a 2012 Warrior III with standard equipment will set you back $289,900, while an average 1974 model brings about $25,000.

The 10-HP boost in power raised the published 75% cruise speed from 116 knots to 121 knots. And the new speed fairings nudged that up to a claimed 127 knots—not exactly blinding, but squarely in league with the Skyhawk, even if easily eclipsed by the Cheetah. Owners told us in no uncertain terms that real-world performance is well less than the book figures: Owners of the 160-HP model reported cruise speeds from 110 to 120 knots. On the good side, the fuel burn at 100 knots can be as low as 8 GPH.

One big gripe by owners of the 150-HP model is a miserable climb rate. "It's taken me to 292 airports in 35 states. As a jack of all trades (master of none), it does not climb rapidly, carry a lot of weight or go fast," wrote one owner of a 150-HP model.

One of the nice features is a generous 50-gallon fuel load (with 48 gallons usable). Burning 7.5 to 10 GPH at cruise, these birds yield a fairly good range with four to six hours of flying. One pilot said he flight planned for 4.5 hours with a 45-minute reserve, and one appreciated the endurance when IFR.

Another owner wasn't happy, saying, "There are times when 50 gallons has been limiting, and I would have liked to have had at least 72 gallons, as did some of the Arrows."

Runway performance is adequate, with an owner of a 160-HP model reporting his being flown from a grass runway. He says the airplane is "adequate for the 2600-foot strip. I'm careful with four passengers on high density altitude days," however, especially if the grass hasn't been mowed.

COMFORT/LOADING

While past respondents rated comfort only as average, the current consensus is it's quite good. Later Pipers benefit from having some of the best seats in general aviation, from both a comfort and crashworthiness standpoint. These seats are designed with an S-tube frame similar to the legendary JAARS seat, which progressively deforms during impact, absorbing energy before it reaches the occupant. For greater pilot comfort, there is an optional vertical seat adjustment that some say is great, but others say is prone to malfunctioning.

The fuel selector is located out of sight alongside the pilot's left knee. The need to switch tanks left and right results in more fuel mismanagement accidents than with the "both tanks" system on the high-wing Cessnas, judging from the

WARRIOR WRECKS: OTHER, RLOC

We've long thought Piper hit a home run when it tapered the wing of the Cherokee 140 and turned it into the Warrior. Our review of the 100 most recent Warrior accidents tends to support that opinion as there is no glaring shortcoming that shows up among the bent metal.

The fact that Warriors are widely used for student training appears in the numbers for landing accidents—although at 36 percent of all accidents, the rate is certainly not high. Runway loss of control made up only 17 percent of all accidents—a decent showing and a reflection, in our opinion, that the wide-track landing gear makes for good ground handling overall.

On the "oops, the landing isn't going well, it's time to go around" front, we have good and bad news. The good news is that we normally see situations where pilots let the airplane get seriously out of control—45 degrees and more off runway heading—before going around and hitting obstructions off to the side of the runway. We didn't see any wild heading excursions, a tribute to the airplane's handling.

On the bad news side of making a go-around in a Warrior, we have to address the manual, or "Johnson Bar," flaps. For decades we have heard pilots praise manual flaps and complain about slow-acting electric flaps. They like the instant ability to increase flap deflection. That's all well and good, but the dirty little secret of manual flaps is that pilots have a tendency to screw up and retract them all at once rather than a bit at a time.

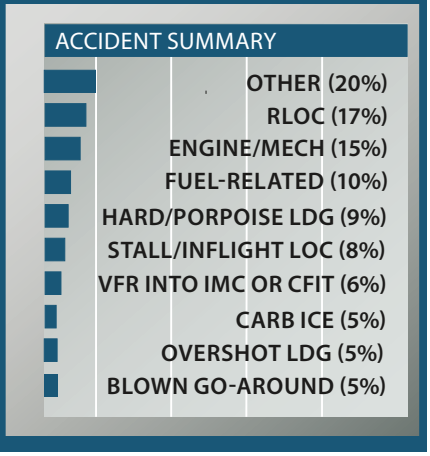
Five Warrior pilots (some were students) were doing fine on a go-around until they dumped all the flaps at once. In each case the airplane stopped climbing—or started descending—and smacked into an obstruction. When dealing with manual flaps, retract them gradually on a go-around.

There were only 10 fuel-related accidents, about what we expect in an airplane where a pilot has to change fuel tanks in flight to get at all of the fuel aboard. While some pilots ran completely out of fuel, several ran a tank dry with plenty of fuel in the other and either didn't even try to change tanks before the subsequent landing or didn't follow the procedure in the POH.

The engine stoppage events were split about half and half between poor maintenance and "we can't explain it." The Lycomings in the Warrior have a reputation for not developing carburetor ice. However, there were five accidents resulting from carb ice. The Cessna 150 and 182 have a reputation for developing carb ice, so pilots are ready for it and there are few accidents. We think that Warrior pilots should be a little more spring-loaded to activate the carb heat when there is a power interruption than they are now.

If it's possible to feel sorry for a machine, we did for the Warriors plagued with such things as a pilot who didn't check Notams to find out the new Unicom frequency at his destination airport. Arriving well after dark he couldn't activate the pilot-controlled lighting. He decided to land anyway—in a ditch between the runway and taxiway. All went reasonably well until he hit a culvert.

Another Warrior driver decided to fly low over mountains at night. He "felt impacts on the left side." After landing he discovered he'd hit trees and fractured the wing spar.



accident reports. Naturally, it's also easy to develop an imbalance unless the pilot remembers to switch regularly, and there is no aileron trim for the airplane. This makes at least a wing-leveler autopilot a nice option, in our opinion.

The Warrior's parking brake is a robust handle sticking out from the bottom of the panel. It's simple and strong, and it works. The same goes for the flap system. It's manual, positive, blessedly simple and it just doesn't break.

Like most low-wing aircraft, however, entry and exit is awkward. The Warrior has only one door, so three of the four occupants have to do some contortions to get in place. Emergency egress is problematical, since the rear windows cannot be opened in an emergency (like those of some Bonanzas, for example). The Warrior's baggage door is fairly large, however.

Naturally, with a full load of 50 gallons, the Warrior won't carry four adults, but some owners report fueling up only to the tabs (34 gallons), accepting the reduced range and legally flying off to their destination. The baggage compartment will take a full 200 pounds structurally, the same as more powerful PA-28s. That's a lot more than the Skyhawk and Cheetah's maximum of 120 pounds, by comparison.

Most owners say nice things about cabin ventilation, thanks to an abundance of outlets, both overhead and underneath. Unfortunately, there were complaints that in winter the overhead vents were too much of a good thing and could not be completely shut off, giving passengers the chills. Pilots have solved this problem by simply taping up the exterior air inlet on the tail in the winter. We also received reports of the heater baking the ankles of those in front while rear passengers froze.

A few owners had the air conditioning systems available as options on the Cherokee line. Those who did felt the cool air yield in summer was not worth the sacrifice in already-limited payload and performance.

HANDLING/COMPETITION

The Warrior shares with the other Cherokees a gentle nature, pleasant handling and such a reluctance to stall aggressively that some pilots

A Warrior's cabin is more utilitarian than posh. Climb in and out from the right wing like every other single-door Cherokee.

rate it a poor teacher. Several respondents said that with both rudder and stabilator trim, the airplane does not need an autopilot.

We'd rate runway handling as good, despite the number of accidents on both takeoff and landing—especially landing—we uncovered in past checks of FAA accident and incident reports. Further investigation revealed that many were student training accidents.

Pilots report they like the way the aircraft handles in a crosswind landing and feel more secure taxiing in windy conditions with the wide gear stance, as opposed to operating in the high-wing Cessnas.

The Cessna Skyhawk and the AGAC Traveler/Cheetah are the most logical competitors to the Warrior for the attention of buyers who want four-seaters that won't break the bank and who are willing to settle for modest performance.

The Cessna has by far the best overall safety record. In a cross-country race, the Cheetah would edge out a 160-HP Warrior with the later wheelpants (the Traveler is slower), and leave the Cessna and the older Warriors in its propwash. And while the Traveler/Cheetah has the most pleasant, facile handling, in our book, it is not as adept at handling short fields. The Cessna gets our nod for getting in and out of little runways.

MAINTENANCE

Here's where the Warrior should shine, since it's the opposite of high-tech sophistication. It's got fixed gear, a fixed-pitch prop, mechanical flaps and a small-bore carbureted engine. It also comes with a cowling providing the best engine access in its class: Doors on either side of the cowling are hinged at the top and secured with double latches. By contrast, gaining similar access to a Skyhawk's engine requires removing several screws and then lifting off the cowling's upper half, a two-person job when done correctly.

As expected, owners report relatively low maintenance costs and modest annual inspection fees. But it's a good thing they have that cowling: The engine compartment is the source of most upkeep problems.

Our checks of Service Difficulty Reports (SDRs) showed a host of problems with carburetors and a number of magneto failures. The powerplant itself was tagged with several failure modes, valves being at the top of the list, followed by camshaft/lifter/pushrod problems, cylinder cracks and rocker arm

Reader Tony Esteves sent the top photo of his nicely kept Warrior II. You'll pay more for personal ones that were pampered, rather than models that live hard lives on a training line. Low-time models in good condition have held (if not increased) their value for several years. In the air, the Warrior gets high marks for not having bad habits, which sweetens the buy decision.

breakage.

Potential buyers should check to see if there is roughness following engine start, since according to Lycoming that's one sign the exhaust valves are beginning to stick. (The roughness usually goes away after the engine warms up, incidentally.)

High-time Warriors usually got that way as a result of being in a training environment. As one result, landing gear components and attach points, along with their fasteners, are subject to numerous cracks and corrosion.

If you're looking at a Warrior equipped with air conditioning, take a look at the bracket that attaches the alternator and compressor. We noted reports that the mounting bolts had broken or worked loose. And in one case the submitter found the bracket was installed backward, subjecting the rear tab of the alternator to stress and misalignment of the pulleys.

MODS/USER GROUPS

One series of mods available from Plane Dynamix (www.planedynamix.com) for earlier PA-28 models also can be installed on Warriors. These include a set of vortex generators, modifications to the standard Sensenich prop blade designed to reduce drag, a new, more-efficient cowling and—for -151 Warriors—an upgrade to 160 HP. We have no direct information on these mods' effectiveness, but Art Mattson (who recently sold the company to Plane Dynamix) has regularly set speed records in his Cherokee 140.

Owners of 1977 through 1982 Warrior IIs can get a gross weight increase, from 2325 up to a whopping 2440 pounds. Mostly a paperwork exercise requiring a placard and carrying a later Piper information manual, the STC gives early -161 owners the same gross weight 1983 and later models enjoy. Ventura Aero (www.ventura.aero) offers this mod.

Another interesting STC involves installing a supplemental storage area under the baggage compartment floor, capable of storing up to 25 pounds. The mod, available from Aircrafters Inc. (www.aircrafters.com), includes parts and paperwork for the conversion.

Other mods include ones from LoPresti Speed Merchants (www.speedmods.com), Met-Co-Aire (www.metcoaire.com) and Knots 2U (www.knots2u.com). These include gap seals and new wingtips—including tips with landing/recognition lights.

As with any personal airplane, we strongly recommend joining its type club. The expertise can save real money when tracking down common parts and problems. Warrior owners are fortunate in that they have an excellent organization, the Piper Owner Society (www.piperowner.org), which merged with the Cherokee Pilot's Association. There is also a Piper Forum (www.piperforum.com) where Piper pilots exchange thoughts.

OWNER FEEDBACK

I have owned my 1980 Warrior II since the year 2000 and I have found it to be a great airplane. The Warrior is not a stretched Cherokee 140. It is a different aircraft and flies much differently.

While the Warrior fuselage is longer and has full rear seats, the Warrior II has a 160-HP Lycoming 0-320 engine, and most significantly the "Warrior wing," which is far different than Hershey bar wings. This wing is longer than an A-36 Bonanza's, and flies significantly different than any of the Hershey bar wings.

With the longer wing the plane glides beautifully. It's really remarkable. In Hershey bar-wing aircraft the ground comes up quickly with power back. Not so in the Warrior. With the

larger wing, however, holding the yoke way back with an overly high AOA on the initial ground run for soft-field and short-field takeoffs is the incorrect procedure and increases the ground roll, so it's important to read the POH when transitioning to the type.

I have found the fuel system to be much better than the "both" cross-feed system on some other aircraft. The low-wing Warrior is easy to fuel and there's a 50-gallon capacity (48 usable), with a tab for partial fills. No bladders mean no fuel leaks. The fuel gauges don't fluctuate and are just as accurate as the gauge in my car. I also have a calibrated dipstick for partial fills, which is remarkably accurate. Between accurate fuel burn rates, confirming gauges and dipstick measurements, I always know exactly how much fuel is where.

The fuel selector is simple to operate with well-defined detents and a stop to prevent inadvertent shut-off. Switching tanks is a non-event, and shutting the fuel completely off requires a deliberate and different action than switching tanks.

My O-320 engine has been quite reliable and it always starts easily—hot or cold weather. It uses less fuel than the O-360 and seems to run smoother. My engine has roller tappet lifters. If you change the oil regularly and maintain the engine, there are no issues with stuck valves, or magneto failures, and the engine cases generally don't crack. The last engine in my aircraft easily made it past the 2000-hour TBO. Obviously, aircraft with crankcase oil that looks like taxiway sealant have issues not normally seen.

I have never needed to use carburetor heat on this engine in any weather, unlike some Continental-powered aircraft where carb ice might be a regular problem.

The cabin door is curved to integrate into the fuselage roof. This clamshell shape gives the door torsional rigidity and it has two points of closure with the top latch so the door closes like a bank vault. If the door seals are well maintained for both the cabin door and the baggage door, the cabin seals nicely with no wind noise or cold drafts. There is plenty of heat available so the back seaters are quite comfortable. Personally, I think the design and build quality of these Pipers is better than Cessna. My plane has no cracked or broken interior plastic.

My aircraft flies beautifully, trims out perfectly and easily makes book numbers. My plane has a new paint job, plus all the wheelpants and fairings (including the nose strut fairing) that came with the plane from the factory, so the plane is aerodynamically clean. Flight school Warriors are typically missing all the pants and fairings for quick maintenance, and the airframes are often in poorer aerodynamic condition so their performance is different. If a thin layer of winter frost can reportedly reduce lift by as much as 30 percent and increase drag by as much as 40 percent then a sandpaper paint finish might do the same thing.

The Warrior has no prohibition on slips with or without flaps. I typically slip and land with two notches of flaps. Forward slips, turning slips and side slips for crosswind landings all work very well. This plane has a pretty high 17-knot demonstrated direct crosswind capability. With the dihedral low wings, crosswind landings are routine and easy. This plane works with you not against you. I don't believe that planes get any easier to fly than this one. However, I believe many accident stats for this aircraft are more often reflective of low-time student mishaps than any fault with the plane.

My Warrior, by way of an STC, has a gross weight increase to 2440 pounds which is really just a paperwork correction to the original POH. The useful load on my aircraft is 921.5 pounds—quite decent—and means I can carry three 200-plus-pound adults (myself included) with full fuel for four hours (more than I need) plus one hour of reserve fuel. I believe this plane has better performance than a similarly powered Cessna 172. Fuel burn at high power settings is around 9 GPH, but powered back for sightseeing the burn drops to around 6 or 7 GPH.

The base cost for annual inspections is around $1200 and full insurance is $950. I'm a retired senior and have found this plane to be an excellent retirement plane. This plane was intentionally designed to be economical and easy to maintain and it fulfills that mission.

It's a well-behaved sweetheart,

Used Piper Warrior

(continued from page 31)

with no bad habits, that is easy to own and operate on a retirement budget.

Tony Esteves
via email

I have a 1979 PA-28-161 Piper Warrior II. It's a pretty straightforward airplane with really no bad habits or surprises. It doesn't do any one, single thing very well but does many things pretty well. It's a stable, easy to fly airplane and normal and cross-wind landings are a breeze. Plus, the manual flaps are simple and reliable.

It's also a pretty easy plane to maintain as most mechanics have experience working on them and parts are easy to obtain. The 160-HP Lycoming O-320 is about as simple as you can get and the Warrior's engine cowling provides great engine access during preflight and maintenance.

At present my Warrior II has older IFR avionics that I am considering upgrading, along with looking into ADS-B. It has a new interior and all-new Plexiglas but could probably use a new paint job at some point

I plan on an honest 110- to 115-knot cruise speed at 8 GPH without wheel fairings. My useful load is just over 850 pounds. The 48-gallon fuel tanks can be partially filled to the tabs (17 gallons per side) allowing for more cabin payload

The single door on the right-hand side really isn't an issue, but I would prefer one on the left, and maybe a push-out window for emergency exit might be nice to add to my wish list.

The baggage compartment can hold 200 pounds, which is 80 pounds more than the Cessna 172. Overall performance is similar to if not a bit better than a Cessna 172.

If speed matters so do wheel-pants. Owners say their Warriors easily make book speeds and better when so equipped.

Maintenance hasn't really been too bad, with annual inspections and maintenance running around $2000-$3000 per year. The tiedown is $60 per month and my insurance runs just over $500 per year for a $40,000 hull value.

Of course everyone wishes their plane was faster, bigger, could carry more and had more range. Still, the Warrior II is really a good compromise. As with any aircraft, if you are considering buying one make sure you have a competent mechanic do a prepurchase inspection on it, while outstanding ADs aren't too bad. Corrosion on the older airframes could be an issue so be diligent on looking for it and correcting it. Piper Service Bulletin 1006 suggests and encourages that you remove the fuel tanks every seven years for inspection. There is a proposed AD out that might require wing spar inspections on certain Piper airframes and, if eventually implemented, could be significant depending on how it is actually written.

Mitch Ross
via email

MOONEY 231/252

It's time again to take a look at the used Mooney M20K market for the *Aviation Consumer* Used Aircraft Guide. We want to know what it's like to own these speedy travelers, how much they cost to operate, maintain and insure and what they're like to fly. If you'd like your Mooney to appear in the magazine, send us any photographs (full-size, **high-resolution**) you'd like to share to the email below. We welcome information on mods, support organizations or any other comments. Send correspondence on the Mooney by July 10, 2019 to:

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