August 2019
Volume LI
Number 8

The consumer resource for pilots and aircraft owners

The Aviation Consumer®

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

AVIATION CONSUMER (ISSN #0147-9911) is published monthly by Belvoir Aviation Group LLC, an affiliate of Belvoir Media Group, 535 Connecticut Avenue, Norwalk, CT 06854-1713. Robert Englander, Chairman and CEO; Timothy H. Cole, Executive Vice President, Editorial Director; Philip L. Penny, Chief Operating Officer; Greg King, Executive Vice President, Marketing Director; Ron Goldberg, Chief Financial Officer; Tom Canfield, Vice President, Circulation.

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

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

THE INSURANCE MARKET HAS HARDENED

You've got the airplane partly configured for landing on a long final and the tower hasn't yet cleared you to land, but says to continue at best speed. To make the airplane go faster, you retract the landing gear and clean up the flaps. Then you're instructed to do a present-position 360 because the sequencing just isn't working out and a Falcon is beating you to the runway. Halfway through your circle, the tower clears you to land, you tuck in on final, put in some flaps and come over the numbers kind of hot. Something definitely isn't right in last two seconds of the flare because the tires aren't touching. But then the propellers do, and so does the belly. At least you've stopped at the first taxiway so they can get your broken piece of metal off the runway quickly so the ramp gawkers can see it hanging off the wrecker. A sickening experience, yes, and a bad ending to an otherwise good business trip with the airplane. But isn't that what insurance is for?

As twisted as those three-blade propellers were, I somberly half-enjoy these stories on a slow day in the editorial office because well, we need field reports, and this report comes from a piston single owner who was subsequently dropped by his insurance company after that exciting day at the home airport when he geared up his airplane. When we looked at the aircraft insurance market six months ago there were signs that the 10-year run that favored buyers could be coming to an end, particularly for turbine aircraft owner-pilots. Some of those customers were being hit with premium increases of 30 percent or more. Some of the brokers I talked with are now reporting that price increases are trickling down to customers flying higher-performance single- and twin-engine aircraft. Moreover, the consensus among aviation insurance professionals is that general aviation underwriting has become generally unprofitable—a trend that actually started several years ago. Why? All of those years of rock-bottom premiums are catching up with the bottom line.

And it wasn't just cheaper premiums for high-end aircraft. Underwriting guidelines had softened and the competitive nature of the soft market meant that some insurers would allow an owner-pilot to attend a structured refresher trainer program every other year instead of every year, as one example. Another more convenient option is letting pilots train in their own aircraft rather than going off to a simulator for the work. Even the numbers changed. As an example, some underwriters relaxed their guidelines on what limits of liability they would offer. But until recently, owners of piston aircraft have seen fewer changes in their premiums, the limits available to them and the training required to stay insured.

From what I can tell, one segment that's getting hit the hardest when it comes to premium increases—and perhaps more likely to get dropped—is aging pilots. No fewer than four older pilots that I've spoken to recently (all over the age of 70) who fly their own turbine aircraft say they've seen substantial increases in their premiums. These are generally accident-free customers who operate everything from single-engine turboprops to light jets. Some told me the underwriter is requiring far more frequent refresher training—like every six months, compared to every year or every other year as they were accustomed. One longtime and loyal customer who flies a turboprop-converted single told me his premium wouldn't be renewed when it expires because the company has stopped insuring that model. He's had no wrecks, flies often and has been a loyal customer.

What might you do if you're feeling the squeeze of a hardening market? Insurance pros all agree that flying and training more frequently make you look good on paper. Loyalty matters, too, so now is not the time to jump carriers. Insurers also look favorably upon customers who earn new ratings. Last, while it goes without saying, simply don't break the airplane. In the good old days of a soft market you might not even see a premium increase after gearing up your twin, but in the current market you could find yourself uninsurable. —*Larry Anglisano*

BACKING UP GARMIN GLASS

I read your review of Garmin's now STC'd G3X Touch integrated avionics suite in the June 2019 issue of *Aviation Consumer* and I think you left something out.

I have a 1981 Cessna P210 and would like to install the G3X Touch when it gets on the AML for my plane. If you look at the Garmin G3X Touch website and keep scrolling down they rather casually mention that for IFR you must retain the vacuum-powered attitude indicator or install the Garmin G5 as well.

That would be a deal breaker for me as I already have a non-Garmin electric attitude indicator for backup and one of my desires is to finally get rid of failing vacuum pumps.

John Davis
via email

We asked Garmin about this requirement and it responded: "Yes, the STC'd G3X Touch does require standbys for an IFR installation like John describes (just like most EFIS/PFD installations). But the good news: A single G5 can take the place of the vacuum attitude, the mechanical airspeed and mechanical altimeter. The G5 attitude instrument is also highly integrated with the G3X Touch. We thought that was a great deal versus having to keep the old iron gyro equipment or install a more expensive electronic standby, like a Mid-Continent Instruments and Avionics MD302, to name one."

ASPEN AND AUTOPILOTS

Having read your coverage of the Aspen E5 budget EFIS, I notice that there is no mention that to interface the display with a legacy autopilot (like a Century 41 that's in my Mooney), you will need a $2795 EA100 adapter, as well as the $1000 ECU. This applies to most legacy autopilots.

This is not mentioned in any of Aspen's advertising. This extra cost is making it a lot more expensive than they lead on.

Mike Fitzgerald
via email

You're correct that analog autopilot interfaces with Aspen displays require the ACU, and if you want ADAHRS roll and pitch drive instead of retaining the attitude gyro in attitude-based autopilot interfaces, you'll need the EA100 emulator.

We did mention the required ACU in the E5 article (February 2019 Aviation Consumer), but didn't talk about the gyro emulator. Our sense is that the entry-level E5 really isn't aimed at interfaces that are this advanced, but instead for basic VFR aircraft and owners looking to get into the world of basic EFIS.

In your case, given your current setup, have your shop price a couple of Garmin G5s, a G3X Touch and an Aspen MAX 1000 and compare it to a Aspen E5. The numbers will be higher than a plain-vanilla E5, but worth looking at.

AIRCRAFT WEIGHING

Thank you for the solid advice in the aircraft weighing article in the July 2019 *Aviation Consumer*. I wish I thought of this when I contracted my shop to install a complete avionics retrofit in my old Bonanza last year. I always suspected that the numbers in the weight and balance report were bogus and thought a new report prepared by the shop would finally set it straight. It didn't, based on the numbers after I had it weighed.

Turns out there was a 28-pound discrepancy (someone never logged the removal of an old strobe light power supply and some other stuff a number of years back), plus the CG was off considerably. To me the service was worth the $600. Thanks for the great service you consistently provide through your work.

Dean Altman
via email

SKYLANE FUEL BLADDERS

The May 2019 review of used Cessna 182s states that early 182s prior to 1962 182E had wet wings. This is incorrect. Models 182 through 182D also had bladders. The original bladders in our 1957 182A were a different material than today's replacements and lasted a very long time—nearly 45 years.

The article is absolutely correct to mention a concern about wet wing tanks leaking as the fleet ages. Doing a proper reseal of a Cessna wet wing is far more difficult than most and it may be difficult to find anyone who will reseal a Cessna wet wing. The forums in www.cessna-pilots.net have an excellent thread on the task.

Abott de Rham
via email

On The Cover: A Cessna 206 Stationair sports a panel of Avidyne retrofit avionics, also interfaced with an Aspen Evolution primary flight display, JPI engine/system display and of course an iPad thrown in the mix. It's a worthy choice, among plenty others we cover in the Top Avionics Upgrade article starting on page 4.

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Top Avionics Upgrades: Choices For All Budgets

With falling prices, blanket approvals and serious integration, it's finally a buyer's market for avionics. But, labor cost and complexity are on the rise.

by Larry Anglisano

ADS-B is old news. Let's equip and move on because the real news in the avionics market is the serious surge in competition, combined with a shift from expensive TSO approvals to STCs. That's working out to the benefit of avionics buyers, especially ones with lower budgets.

Adding to the competition are newcomers, with New Mexico-based Aerovonics as one example. As we reported in the July 2019 *Aviation Consumer*, this new company's AV-series primary EFIS is capable and smartly engineered, with a price that caters to low budgets and an installation that doesn't require shredding the instrument panel.

Of course the dense market doesn't make an already difficult buying decision any easier. So to help sort it out, in this article we'll offer an around-the-bases look at the most popular new avionics configurations—from entry-level (for basic aircraft) to higher-budget (for go-places higher-end machines). The idea is to arm you with enough knowledge to talk the talk with your avionics shop when they make suggestions for a package. It's also time for our ADS-B buyer's guide, and it follows this article. Let's begin with an ADS-B wrap-up.

DON'T OVERTHINK IT

At this point the ADS-B buy-in decision should be easy. You've heard it all before but we'll tell it to you again: If you fly above 18,000 feet, you'll need an ADS-B transponder. And if your existing transponder is an aging non-digital (has a cavity oscillator tube) model, our advice is to ditch it and put in an ADS-B transponder. Old models worth getting rid of include the King KT76/78 series and anything made by Narco or Collins. If there's any doubt about its health, have your shop evaluate it. You'll need a reliable unit for the long term.

If you've already invested in a modern transponder upgrade and don't fly above 18,000 feet, one top pick is the uAvionix skyBeacon wingtip unit with LED position and strobe lamps. We've covered this system extensively, and most recently in the May 2019 *Aviation Consumer* where we installed one in a Piper Cherokee to see if it really was the world's easiest ADS-B upgrade as the company claims.

Turns out the claim was close enough to crown the skyBeacon a winner for a budget-based solution, the deal sweetened with a two-for LED lighting upgrade. Realistically, you'll want to budget $2000 for an easy installation (including the strobe light), paperwork and flight testing, and a bit more if the light doesn't exactly bolt directly in place of the existing lamp assembly.

If you already have a healthy and modern transponder and you don't plan to fly high, Garmin's GDL82 UAT solution sells for $1795—the second cheapest. The datalink processor connects in line with the existing transponder antenna

CHECKLIST

- For roughly $3000, you can get an entry-level primary EFIS.
- The current STC certification trend is lowering prices and broadening applications.
- A fully integrated panel with new autopilot and ADS-B can approach or exceed $50,000.

That's a Garmin G500TXi display with integrated engine indication system (EIS) on the pilot's panel of a Mooney. The iPad in the right stack connects via Bluetooth to the GTN750 for ADS-B traffic, weather and flight instrument display. The clean retrofit was done by SureFlight Aircraft Completions in Pennsylvania.

Avionics configurations are all over the map. The Skyhawk in the top photo has a Garmin G5 flight instrument, GNC175 IFR navigator, L3 NGT9000 ADS-B transponder and leftover analog radios from the 1980s. That was a $15,000 investment. Garmin's GNX375, middle, is an IFR navigator with built-in ADS-B transponder. In the "one-to-watch" category, the panel in the lower photo has a pair of Aerovonics AV30 flight instruments. Call that a $5000 job.

and has a built-in WAAS GPS. The installation requires mounting the GPS antenna on the cabin and wiring the unit.

But as budget-based as these solutions are, shops still report that the most popular ADS-B upgrade is Garmin's GTX345 ADS-B In and Out transponder. It's available with and without WAAS GPS and has built-in Bluetooth for sending flight data, ADS-B traffic and weather data to a tablet or smartphone running the Garmin Pilot or ForeFlight tablet apps. It's a generous interface. Pricing on the base GTX345 (without GPS) is $4995. Got an existing GTX330 Mode S unit? Garmin will upgrade it to the GTX330ES, which has ADS-B Out, but requires a WAAS GPS input.

TOP EFIS UPGRADES

Of all the avionics upgrades, planning a primary flight display retrofit is perhaps the most difficult. There could be major panel work involved, and it might not work fully with your autopilot.

Step one is to evaluate the existing flight instruments and look toward the future. If the aircraft has traditional round gauges, do you want to get rid of the vacuum system in favor of an all-electric suite? If so, does the product's STC include removing the vacuum system? There's good reason to consider going vac-less. Other than the obvious boost in confidence and reliability, getting rid of all that hardware sheds sizable weight and clutter behind the instrument panel.

Your Garmin dealer's most likely top recommendation for a lower-end EFIS upgrade might be Garmin's $2249 G5 display, of which there are two. It's a worthy suggestion, in our view. The G5 has an STC that currently covers 560 aircraft models—a huge swath. In its basic form, a single G5 attitude indicator can be installed as primary. It has a battery backup in case of electrical failure and can be paired with the $2549 G5 heading/electronic HSI instrument for dual ADAHRS redundancy. If the G5 attitude instrument fails, the directional instrument reverts to an attitude display.

Connecting the G5 directional instrument to third-party autopilots and earlier GPS navigators requires the $699 GAD29B nav interface module. Once the dust settles, typical dual-screen G5 installations generally run around $7000.

On the higher end, Garmin has a widespread STC for the once experimental G3X Touch. We covered the G3X Touch in a flight trial article in the June 2019 *Aviation Consumer* so we'll just recap it here. When planning the G3X Touch, first consider which screen configuration works best for the panel and the budget. What makes this system our top pick for a high-end EFIS is the number of display options and the 500-plus approved model STC.

It's a brisk market for retrofitting early-gen Cirrus models. That's a G2 SR22 worked over by Nexair Avionics in Massachusetts with dual Avidyne IFD navigators, an Avidyne DFC90 autopilot and a PS Engineering audio system. What you don't see is Avidyne's AXP322 remote ADS-B transponder. Call it a $50,000 upgrade. That's the attitude-equipped IFD550, middle, and the JPI EDM930 primary engine monitor, bottom.

It's worth mentioning Garmin's G500/600TXi PFD/MFD, which came out before the G3X Touch was certified. Unlike the G3X Touch, the TXi displays have full TSO approval, plus the system is deeply compatible with analog third-party systems, including legacy autopilots. Contrast that with the G3X Touch, which essentially requires a Garmin navigator for its digital data bus interface. With the TXi, you can interface your analog KX155 nav radio, as one example.

When deciding on either system, ask your shop what makes the most sense from a compatibility standpoint. The TXi is also available with Garmin's EIS engine indication system and is available in multiple screen configurations.

There's roughly a $6000 greater price delta between the 10-inch G500TXi ($15,995) and the 10-inch G3X Touch. The basic, bare-bones G3X Touch with a 7-inch screen is $7995.

If you already invested in Aspen's Evolution retrofit EFIS, you probably recognize that the system can use a jumpstart in processing speed and graphics display. That's just what Aspen offers with the Evolution MAX displays. The MAX, which is available in one-, two- and three-screen versions (just like the original Evolution), is designed as a drop-in replacement for the older displays. But if you want to connect the new display's audio output feature, your shop will need to wire it in to the audio panel. We think the effort and cost is worth it given the added utility, including "minimum" callouts when on an approach.

After flying the new MAX system in a Cirrus (splashed with bright Florida sun), we think the new display technology is impressive—perhaps one of the most sunlight-readable PFDs on the market. Better yet, the Max gives existing Aspen owners an upgrade path, plus it runs upgrade promotions (currently $4995) and can upgrade your existing display or send your shop an exchange. All upgrades get a fresh two-year warranty.

AVIDYNE'S ARS: GPS WITH ATTITUDE

For belt-and-suspender backup that's self-contained in the radio stack, we think Avidyne's IFD550 navigator is a worth a look, especially if you're looking to step up and out of an aging Garmin GNS530. The 550 is a follow-on product to the IFD540 (and smaller IFD440) and these are drop-in replacements for Garmin GNS530W navigators. This means in those applications there is limited rewiring required.

At first glance the Avidyne IFD navigator product line may seem

IS IT READY YET?

That's not a question the typical avionics shop manager wants to hear from an owner when the airplane is still in pieces on the hangar floor. It's more like "we'll call you when it's ready." Truth is shops are feeling the squeeze of the last-minute ADS-B rush and that's not helping the turnaround time on even basic installations.

At smaller shops, techs are often pulled away from install projects for troubleshooting and other tasks. Add to that interface learning curves and you might find the project took twice as long as proposed. Be realistic and don't schedule important trips with the aircraft until you know everything will work. Larger jobs require multiple shakedown flights and oftentimes return visits to the shop to fix. There are exceptions, but shops generally don't fly the aircraft unless the owner is aboard, so you'll need to make yourself or someone else authorized by you available to do the test flying.

Other delays—and cost overruns—are simply the result of aging airframes. Realize that when you get into a large project like retrofitting a Garmin G3X Touch or Dynon HDX, there will likely be items that need replacement. Static systems are one of the more neglected parts of the airframe, and what might have worked with mechanical static air instruments might not work with the sensors in a digital PFD, which are less tolerant to leaks. Now is also the time to rework the electric bus; replacing the circuit breakers, adding or replacing an avionics master switch and installing avionics cooling fans add to downtime.

Of course this is if you can even get on a shop's schedule. Some shops are scheduling nine months out, while six months is more typical. From what we've heard from customers, buyers with larger invoices get priority scheduling, plus there's little if any negotiating on price no matter the size of the project.

confusing, but it doesn't have to be. What differentiates the IFD550 from the IFD540 is the IFD550's ARS, or attitude reference system.

Other than accepting a heading input from Aspen's Evolution PFD, in addition to Garmin's G500/600 PFD, the Avidyne ARS is self-contained. The navigator also sends GPS nav and course data into the displays over an ARINC 429 data stream. For dual installations (maybe an IFD550 and IFD440), the connections are independent for redundancy, but have full synchronization.

Avidyne was the first with a hybrid user interface, which means you use a combination of touch and button presses. There's also an extensive wireless (Bluetooth and Wi-Fi) interface for connecting the IFD to external devices, including an iPad running Avidyne's IFD100 app, in addition to ForeFlight. In fact, the IFD100 app essentially adds a second IFD550 display/control set on the tablet. The navigator also connects to a Bluetooth keyboard as yet another option for data entry.

The list price of the IFD550 is $21,999, but if you have a clean and fully functional Garmin GNS530W, you can cut that cost substantially. We've see trade values as high as $8000.

ENGINE MONITORS

We're putting the finishing touches on an engine monitor roundup for a future issue of *Aviation Consumer,* but we'll give you a brief primer here. We'll start by saying that primary monitors (ones that are approved to replace all of the OEM gauges—including fuel quantity) require a sizable installation. Given their size, expect your shop to do substantial panel rework to make the big-screen display fit

We like that the Aspen Evolution MAX, pictured here, is an affordable plug-and-play upgrade for existing Aspen owners. These next-generation Aspen displays have faster processors, brighter screens and more functionality.

If you're in the market for a new autopilot, there have never been so many choices at the $10,000 price point. Clockwise from the top: The digital Genesys S-TEC 3100 has a growing STC list and is a good value because it work with existing S-TEC autopilot servos, saving a sizable amount of installation time. It's also intended as an easy replacement for the S-TEC 55-series autopilot with minimal rewiring. That's the Trio Pro Pilot autopilot, which also has a growing STC list and some smart features as standard. Garmin's GFC500 started life as an autopilot for experimental aircraft, but now has a sizable STC list for certified aircraft. It's big on features, small on size and works with the Garmin flight displays. The TruTrak Vizion has a straightforward installation. Ask your shop what models are approved for your aircraft and price them all.

in a location that's within your scan and reach. If you have aging fuel senders, expect to either have them overhauled or in many cases replaced with digital senders that may prove far more accurate than older analog senders. This adds big to the installation effort and bottom line.

As we've reported, the once-popular Xerion Auracle big-screen monitor has been orphaned. This was once a flagship monitor with a good display. The good news for owners left in the cold is that many of the probes and sensors for this system can work with a JP Instruments engine monitor, including the EDM930. It's one of our top picks for a retrofit big-screen engine display. The Electronics International MVP-50 is another. We'll hammer out the difference in the upcoming market scan. As for price, realistically you'll want to budget $10,000 or more for some installations, which makes integrated systems like Garmin's EIS on the G3X Touch and TXi displays worth considering.

REALISTIC EXPECTATIONS

A few words on avionics projects. Before even asking a shop for a price quote, bring them the aircraft. They need to see the wiring and the antennas, and if the upgrade includes an engine display, they'll want to eyeball the engine bay.

Don't underestimate the learning curve that tags along with a new suite, especially if it includes a new-to-you GPS navigator. Use the downtime to hit the pilot's guides. If your instincts are telling you that formal training is in your future, limit your flying to decent weather. Accept that you'll be a test pilot for a few hours. And an airplane that's been all over the hangar floor for a month or longer—now with unfamiliar avionics—is a poor match for the nonproficient pilot.

It's a buyer's market with lots of choices. Now is a good time to invest, but don't let lower prices fool you into thinking even a basic upgrade will be inexpensive. Expect overruns and long downtimes.

Shop labor effort and rates are at an all-time high and good shops are busy. Pick one and work to maintain a good relationship. You'll need them for support, including software and hardware upgrades as the systems mature.

MANDATE-COMPLIANT, PANEL ADS-B PRODUCTS

PRODUCT	ADS-B SPECS	DISPLAY INTERFACES	PRICE	COMMENTS
APPAREO				
STRATUS ES	1090ES ADS-B TRANSPONDER	N/A	$2495	Requires WAAS GPS input (Garmin, Avidyne).
STRATUS ESG	1090ES ADS-B TRANSPONDER	N/A	$2995	Has internal WAAS GPS, interfaces with select Stratus portable ADS-B receivers.
ASPEN AVIONICS				
NGT-9000	1090ES ADS-B TRANSPONDER DUAL-BAND ADS-B IN	EVOLUTION MFD, SOME GARMIN AND AVIDYNE DISPLAYS	$2645	L3 Avionics product sold by Aspen. $795 software unlock required to interface traffic/weather with Aspen display.
AVIDYNE				
AXP340	1090ES ADS-B TRANPONDER	N/A	$3995	Partial plug-and-play with some existing BendixKing transponders. AXP322 is remote version.
AXP322	1090ES ADS-B TRANSPONDER	IFD NAVIGATORS	$3995	Remote version of the AXP340. Tuned through the IFD-series navigators.
SKYTRAX100	978 UAT IN	ALL IFD NAVIGATORS	$2199	Display compatibility with several third-party systems for ADS-B In, including Garmin GTX345, L3 Lynx 9000 Series, and FreeFlight RANGR UAT.
BENDIXKING				
KT74	1090ES ADS-B TRANSPONDER	N/A	$2999	Partial plug-and-play with KT76A/C, KT78A transponders, requires WAAS GPS input.
KGX130	978 UAT IN	IOS TABLET MFD TRAFFIC ONLY	$1489	ADS-B In only, for use with 1090ES transponder.
KGX150 (G)	978 UAT OUT, 978 UAT IN	IOS TABLET MFD TRAFFIC ONLY	$4069	Has internal WAAS GPS.
KGX150	978 UAT OUT, 978 UAT IN	IOS TABLET MFD TRAFFIC ONLY	$3489	Version without internal WAAS GPS.
FREEFLIGHT SYSTEMS				
FDL-978-RX	ADS-B IN	MFD, TABLETS	$3161	Works with a Wi-Fi module for display on tablet computers and select panel displays.
FDL-978-RX/G	ADS-B IN	MFD, TABLETS	$3995	Same as the FDL-978-RX, but with a built-in GPS.
FDL-978-XVR	978 UAT OUT, 978 UAT IN	IOS TABLET MFD TRAFFIC	$3935	Single-box solution that works with Garmin GNS430W/530W navigators, works with a Wi-Fi module for connecting to tablets.
FDL-978-XVR/G	978 UAT OUT, 978 UAT IN	IOS TABLET MFD TRAFFIC	$4980	Same as FDL-978-XVR but with internal WAAS GPS.
FDL-1090-TX	1090ES ADS-B TRANSPONDER	N/A	$4495	Remote control head/processor design, requires WAAS GPS input.
GARMIN				
GTX330D W/ES	1090ES ADS-B TRANSPONDER	N/A	$8637	Diversity Mode S transponder with ADS-B Out when connected with an appropriate WAAS GPS.

GTX335	1090ES ADS-B TRANSPONDER	N/A	$2995	Internal WAAS GPS.
GTX345	1090ES ADS-B TRANSPONDER	GTN750/650/G1000, G1000TXi, TABLETS, G500TXi, G600TXi	$4995	Internal WAAS $5795, GTX345-R LRU priced the same and works on G1000 NXi, G2000, G3000, G5000.
GDL82	978 UAT OUT	N/A	$1795	Designed to work with and connects to the existing Mode A/C transponder.
GDL84	978 UAT OUT, DUAL-BAND IN	IOS, ANDROID TABLETS	$3995*	Standalone ADS-B Out and In, wireless Bluetooth connectivity with Flight Stream 110/210. Requires Garmin Pilot, ForeFlight tablet app. *$4495 with Flight Stream 210 (built-in AHRS).
GDL84H	978 UAT OUT, DUAL-BAND IN	IOS, ANDROID TABLETS	$3995*	Standalone ADS-B Out and In, wireless Bluetooth connectivity with Flight Stream 110/210. Requires Garmin Pilot, ForeFlight tablet app. *$4495 with Flight Stream 210 (built-in AHRS), version for helicopters.
GDL88	978 UAT OUT, DUAL-BAND IN	GNS530W/430W GTN750/650 G600/500/TXI/G3X *IOS/ANDROID	$3995	Requires WAAS GPS input, tablet interface requires Flight Stream wireless Bluetooth module, Garmin Pilot or ForeFlight app.
GDL88-W	978 UAT OUT, DUAL-BAND IN	GNS530W/430W GTN750/650 G600/500/TXI/G3X *IOS/ANDROID	$5143	Has built-in WAAS GPS receiver, tablet interface requires Flight Stream wireless Bluetooth, Garmin Pilot or ForeFlight app.
GDL88-D	978 UAT OUT, DUAL-BAND IN	GNS530W/430W GTN750/650 G600/500/TXI/G3X *IOS/ANDROID	$4495	Diversity model (requires top and bottom antenna installation), requires WAAS GPS input, tablet interface requires Flight Stream wireless Bluetooth module, ForeFlight or Garmin Pilot app.
GDL88-WD	978 UAT OUT, DUAL-BAND IN	GNS530W/430W GTN750/650 G600/500/TXI/G3X *IOS/ANDROID	$5643	Has built-in WAAS GPS receiver, diversity (requires top and bottom antenna installation), tablet interface requires Flight Stream wireless Bluetooth module, ForeFlight or Garmin Pilot app.
GDL88-DH	978 UAT OUT, DUAL-BAND IN	GNS530W/430W GTN750/650 G600/500/G3X *IOS/ANDROID	$5395	Diversity and the version made for helicopters.
L3 AVIATION LYNX				
NGT-9000D+	1090ES ADS-B TRANSPONDER DUAL-BAND ADS-B IN	HAS WAAS GPS, TOUCHSCREEN, DISPLAYS TRAFFIC AND WEATHER ON SOME ASPEN, AVIDYNE AND GARMIN DISPLAYS	SEE DEALER	Supports diversity (top and bottom antenna), displays TIS-B, FIS-B ATAS (ADS-B Traffic Alerting System), includes Active Traffic (Interrogates Non-ADS-B Aircraft). Option—Terrain Vision $895. Option—TAWS $4000.
NGT-9000+	1090ES ADS-B TRANSPONDER DUAL-BAND ADS-B IN	HAS WAAS GPS, TOUCHSCREEN, DISPLAYS TRAFFIC AND WEATHER ON SOME ASPEN, AVIDYNE AND GARMIN DISPLAYS	SEE DEALER	Displays TIS-B, FIS-B ATAS (ADS-B Traffic Alerting System), includes Active Traffic (Interrogates Non-ADS-B Aircraft). Option—Terrain Vision $895. Option— TAWS $4000.
NGT-9000	1090ES ADS-B TRANSPONDER DUAL-BAND ADS-B IN	HAS WAAS GPS, TOUCHSCREEN, DISPLAYS TRAFFIC AND WEATHER ON SOME ASPEN, AVIDYNE AND GARMIN DISPLAYS	$5433	Displays TIS-B, FIS-B ATAS (ADS-B Traffic Alerting System), includes Active Traffic (Interrogates Non-ADS-B Aircraft). Option—Terrain Vision $895. Option—TAWS $4000.
TRIG AVIONICS				
TT31	1090ES ADS-B TRANSPONDER	N/A	$2225	Stack-mounted, requires WAAS GPS input.
TT22	1090ES ADS-B TRANSPONDER	N/A	$1989	Two-piece system, requires WAAS GPS input, compact.
UAVIONIX				
SKYBEACON	978 UAT OUT ONLY	N/A	$1849	Wingtip mount with WAAS GPS, LED nav light, LED strobe light. TSO certified, STC for installation pending.
TAILBEACON	978 UAT OUT ONLY	N/A	$1999	Tail mount version. Pending TSO certification.

Electronic Ignition: Coming of Age

A second electronic ignition system has received certification. We like the choices now available for those who want to get rid of one magneto.

by Rick Durden

Pilots have flown behind magnetos since there was dirt because they're reliable and simple—even though they wear out faster than any other component in an airplane. However, since electronic ignition for piston engines first proved itself as reliable and much more capable when it comes to engine efficiency and power, pilots have been cursing the time it has taken for the concept to evolve into little airplanes.

Fortunately, there has been a small, dedicated group of people who have been wrestling with the challenges and staggering costs of FAA certification—and it's paying off.

The good news is that there is now a second purveyor of certified electronic ignition systems. The better news is that prices are low enough that it may make economic sense to make the installation in the family flying machine.

In this follow-up we'll talk a little about electronic ignition's benefits and then about the two industry leaders, Electroair (www.electroair.net) and SureFly (www.surefly.aero).

WHAT'S IT DO?

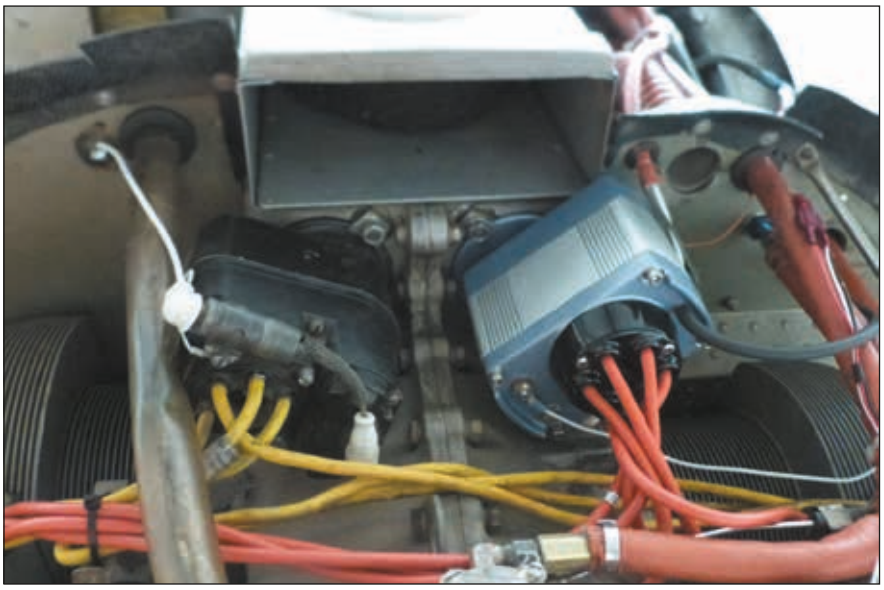
Electronic ignition allows a spark plug to be fired at precisely the right time, for the right length of time and with the energy to optimize the power and efficiency of the combustion event. The more of the fuel/air mixture in the cylinder that burns, in the right amount of time, in the right fashion, the greater the energy obtained from that bit of avgas.

A byproduct of a hotter, longer-lasting ignition source is fewer fouled plugs. It may also make starting easier.

Magnetos always fire the spark plugs at the same point—on the order of 25 degrees before top dead center (TDC)—and rely on the combustion event to carry on by itself to reach maximum pressure by the time the piston reaches 11 to 17 degrees past TDC. Mags put out a spark of on the order of 12,000 volts. The downside: At 500 hours it's time to pull mags for inspection and repair or replacement. That's not cheap.

Electronic ignition uses the wonders of microprocessors to optimize the spark's timing, intensity and length. To start with, variable timing, by itself, allows the engine to produce more power by adjusting when the spark starts according to

That's a SureSureFly electronic ignition module next to a traditional mag, top. Spencer Suderman holds the record for number of turns in an inverted flat spin—98. He teamed with Electroair using its Electronic Ignition System to get more power out of the normally aspirated engine in his Pitts. Entry altitude was 24,500 feet.



The SureFly SIM mounts to the engine just as a conventional mag does.

the conditions in which the aircraft is flying. Electronic ignition also provides power to the spark plug for a longer time, which, combined with higher voltage—70,000 in Electroair's system—generates a much more robust combustion event.

ONE MAG

Currently, both Electroair and SureFly systems replace just one of your aircraft's magnetos. That's the result of a pretty ruthless cost/benefit analysis. We were told by Electroair co-owner Mike Kobylik that replacing one mag with electronic ignition gives 85% of the benefits that can be derived with both sets of spark plugs fired by electronic ignitions. The problem is that the cost of going to dual electronic ignition is so high that it wipes out the additional 15% increase in efficiency.

To start with, the electronic ignition has to have a source of power. With one unit installed, it runs off of the aircraft's battery. For certification purposes, the FAA frowns on a single point of catastrophic failure. With a single electronic ignition and a single mag, if the mag slips its mortal coil, the electronic ignition carries on.

If the power source for the electronic ignition fails—say the alternator fails and you run the battery flat—the magneto keeps the fan turning.

If there were two electronic ignitions, there would have to be two independent sources of electrical power. That's expensive.

WASTED SPARK

Once one mag has been replaced with an electronic ignition system the remaining mag still fires at 25 degrees before TDC, even when the electronic ignition has advanced the timing. The magneto causes its plugs to fire even though the combustion event is underway—so its spark is wasted, so to speak. Naturally, that's why the single-magneto electronic ignition system is called a wasted spark system.

The reality is that having a 12,000-volt spark in the midst of a combustion event fired by a much higher-energy spark doesn't affect what is already happening as the fuel-air mixture torches. The mag is still there, faithfully performing its function. If the electronic ignition system fails, the magneto will keep the engine running happily.

This is probably the point to mention that whether you have two mags or one mag and an electronic ignition system and you experience engine roughness in flight, troubleshooting includes doing a mag check. Yes, it's OK to check the mags in flight.

If you find that one mag, or the electronic system, is causing the roughness, shut it off. Continuing to allow a malfunctioning mag (or electronic ignition) to run risks the mistimed spark causing preignition and/or detonation, which can cause catastrophic damage to the engine.

SUREFLY

A company that evolved from the makers of two popular general aviation products, Sky-Tek starters and Plane-Power alternators, SureFly branched out into the electronic ignition world. The proprietors had the grit and determination to work through the process of the FAA requiring that they obtain both an airframe and engine STC for what it refers to as the SureFly Ignition Module (SIM). We trust the certification budget included some money for champagne—they got the STCs for single-engine, non-turbocharged airplanes in February of this year. (SureFly is working to expand the STCs into twins, turbocharged, supercharged and turbo-normalized engines.)

General Manager Jason Hutchison told us that the company goal was to create an electronic ignition that would replace one mag inexpensively, use the existing drive gear and be maintenance-free.

The SIM converts aircraft battery power into a high-voltage signal that is directed to the appropriate spark plug for the appropriate time. The unit is about the same size and weight as a Slick mag. It has no moving parts and does not require software updates.

Hutchison told us that a SIM needs zero maintenance. After 2400 hours of use all that is required is to pull it and send it back to SureFly "to let us take a look at it." Hutchison said he expects that the 2400-hour number will be increased with experience in service.

There are four models of the SIM, covering most four- and six-cylinder engines.

The SIM can be adjusted to any engine's base timing advance (the information is on the engine data plate) by a switching module. The unit controls timing by sensing engine manifold pressure and RPM. Below 400 RPM the timing is set to TDC, with a longer dwell and increased voltage to ease starting, particularly on cold days or with fouled plugs.

The initial STCs did not allow the

ELECTROAIR IGNITION SWITCH PANEL

During Electroair's development of its electronic ignition system (EIS), the company observed significant owner dissatisfaction with the rotary key ignition switch that is standard in most airplanes.

Pilots who had flown twins and the Citabria/Decathlon series singles expressed a preference for a push-button starter and toggle switches for the mags. Owners also said that while they were used to complying with the AD requiring an annual inspection of the rotary ignition switch, they'd prefer not to have to deal with it.

Electroair developed two ignition switch panels that provide a starter button and toggle switch and eliminate the risk of faulty contacts within a rotary key switch, cutting down on the chances of a hot mag.

Both are priced at $269, and come in horizontal or vertical orientation. The EA-1300 (shown at left) is designed to control one Electroair EIS, one mag and a starter. The EA-1500 is designed to control two magnetos and a starter.

Installation requires finding panel space, so the cost will vary with the type of airplane. Personally, we like not having to worry about strapping in and then discovering that the key is in our pocket.

SIMs to advance engine timing in flight; however, the FAA has been rapidly issuing approvals for variable timing. The good news is that the process of changing a SIM from fixed to variable timing takes only a few minutes and involves removing it, changing DIP switches and reinstalling it.

A SureFly SIM controls spark advance up to 38 degrees before TDC. The timing advance schedule is set at the factory, so there is nothing that ever needs field adjustment. SureFly's intent was to create an install-and-forget unit—there are no requirements for maintenance once in service other than to pull it at 2400 hours.

INSTALLATION

SureFly advertises installation of a SIM in one hour. After watching a video of installation on a Grumman Cheetah, we think that the number may be about right for a technician who has done it once or twice. With signoff, we think two hours is realistic.

Installation consists of connecting the power wire to the aircraft's electrical system (protection is a slow-blow fuse, not a circuit breaker). The SIM is turned on and off with the existing ignition switch through the P-lead wire connected to the P-lead terminal of the SIM.

The next step is to remove the magneto—on a four-cylinder engine the magneto gear is moved to the SIM.

The SIM's timing is then set to TDC and the SIM installed and DIP switches set for fixed or variable timing.

A Slick-style ignition harnesses is required. If it's already on the engine, it is reattached. The P-Lead is attached to the P-Lead terminal and the manifold pressure line is run from the fitting on the SIM to the appropriate source on the engine.

That's it.

If variable timing is desired, the STC requires that the aircraft have a method of monitoring cylinder head temperature—to us that means an engine monitor. The system is limited to 100LL avgas, no mogas.

The four-cylinder SIMs are priced at $1250, with the six-cylinder models at $1550.

SureFly does not advertise increased performance, but Jason Hutchison said that he's noticed that SIMs allow engines to run better lean of peak, improving fuel economy, and that they may maintain 75% power to slightly higher altitudes.

In our conversation with Hutchison, he did not emphasize performance enhancement as the target for SureFly —their goal was the reliability and economy of an install-and-forget magneto replacement.

ELECTROAIR

Electroair certificated its first electronic ignition system (EIS) back in 2011. As of now, it has STCs for installation on more than 500 models of airplanes, with the number continuing to increase. Electroair's high-energy, tuned electronic ignition system is approved for piston singles and twins, with normally aspirated, turbocharged, supercharged or turbo-normalized engines.

With the company based near the automotive racing hub of Detroit, Michigan, it's not surprising that the EIS developed by Electroair came from the racing world and was designed from the start to improve performance and reduce fuel burn.

Electoair's EIS is a more sophisticated approach to electronic ignition than that of SureFly. It replaces the standard spark plug wires with high-tension leads that can handle the load needed to produce a very high-energy spark.

In addition to the high-tension cable leads, the system has four main components: a manifold pressure sensor, direct-fire coil pack, electronic control unit and a mag timing housing.

NO MAINTENANCE

As with SureFly, the Electroair EIS is an install-and-forget system. However, there is no requirement to pull it and look it over after a given number of hours. It has no published life limit.

Engine timing is picked up by the EIS using a "60 minus 2 tooth" trigger wheel with a single magnetic pickup; it provides a high-resolution signal feeding continuous RPM information to the control unit. Electroair's Mike Kobylik told us that it's similar to the automotive

High-tension cable leads curve around components of Electroair's EIS for four-cylinder engines, upper photo: clockwise from upper left, controller, mag timing housing, coil pack and manifold pressure sensor. The smaller wires tie the system together. Six-cylinder EIS with coil pack on the firewall and one magneto replaced with the mag timing housing for the EIS, lower photo.

units of the 1980s that had the sophistication to give performance and mileage gains on unleaded fuel. (The Electroair EIS STCs do not have any limitation on fuel types; it can handle 100LL and mogas.)

The dual microprocessor electronic control unit receives RPM and manifold pressure information and advances the timing to compensate for altitude and throttle position based on proprietary and patented algorithms. Timing can be advanced as much as 20 degrees.

Because of the sophistication of the Electroair EIS, the airplane does not have to have any sort of engine analyzer or CHT indicator installed as with SureFly.

70,000 VOLTS

The direct-fire coils are the reason the system can produce 70,000 volts to the plugs. In addition, the spark produced lasts through 20 degrees of crank rotation versus five for a mag.

Owners we talked with confirmed that the power of the ignition improved starting and reduced plug fouling. Because it does reduce plug fouling, Electroair recommends installing it on the bottom plugs as they are more prone to fouling.

COST

Price for the four-cylinder system is $2950; $4950 for the six-cylinder EIS. Installation time varies because of the condition and configuration of the engine room in legacy airplanes. We think target numbers are two days for the four-cylinder EIS and three for six-bangers. Maintenance techs told us that it's wise to go over the installation instructions carefully before doing anything—they're on the website. One tech recommended looking over the installation instructions before buying to assure that the needed components can be installed on the target airplane.

Highly experienced A&P wrench swingers and pilots make up Electroair's customer support staff. The company encourages calling with questions. Electroair has also set up a network of installation centers and is continually adding more.

Electroair's selling point is performance, largely due to its capability to put out a very hot, long-duration spark. The company forecasts a fuel saving of one to two GPH and some degree of cruise speed increase. The benefits increase with altitude—and customers report being able to routinely climb to higher cruise altitudes.

CONCLUSION

We like the options now available to owners who want to take advantage of electronic ignition. For the owner who just wants to get rid of a magneto with its many moving parts and 500-hour remove-and-do-something requirement, SureFly's price and ease of installation are a no-brainer. Because the intensity of the spark is not as great as with the more sophisticated Electroair EIS, we think any performance increase that results will be a bonus.

For those who want the reliability of electronic ignition plus the performance and efficiency gains it can generate, we think the more expensive Electroair system is the way to go and has the potential to pay for itself over a few years.

Digital Fuel Quantity: More Than a Display

Don't shortchange a new engine display system by ignoring the fuel quantity sensors. Overhauling may work, but replacement might be the only fix.

by Larry Anglisano

If you're considering upgrading to an all-in-one engine display that also replaces the OEM fuel quantity gauges, there's the potential for disappointment. Sure, a digital fuel indicator solves the nuisance sticky/bouncing needle that plagues older systems but it might not make the system any more accurate. That's because the new display is only half the interface. The critical part of the system—the fuel quantity sensors—live deep in the fuel tank.

With engine display upgrades becoming more common than ever, we're hearing plenty of stories from owners frustrated with their installers when the new system ends up being less accurate than expected. In our view, whether you're investing in a fully integrated suite like a G3X Touch or SkyView HDX, or a standalone engine display to replace the OEM gauges, it pays to spend the time and money to repair or replace the fuel senders.

Here's a primer, with also some guidance for upgrading even when a big-screen monitor isn't your plan.

LIMITED SHOP SUPPORT

That's what you'll likely find when your aircraft is in for an engine display upgrade and your avionics shop suggests—as they should—to overhaul or repair the fuel quantity senders. Aside from having to drain the fuel tanks, this creates extra work for the installer because chances are they'll have to send the sensors off for overhaul. We've found that for some shops, dealing with old OEM sensors is uncharted territory. The task has to begin with good documentation, and that includes having the aircraft maintenance manual.

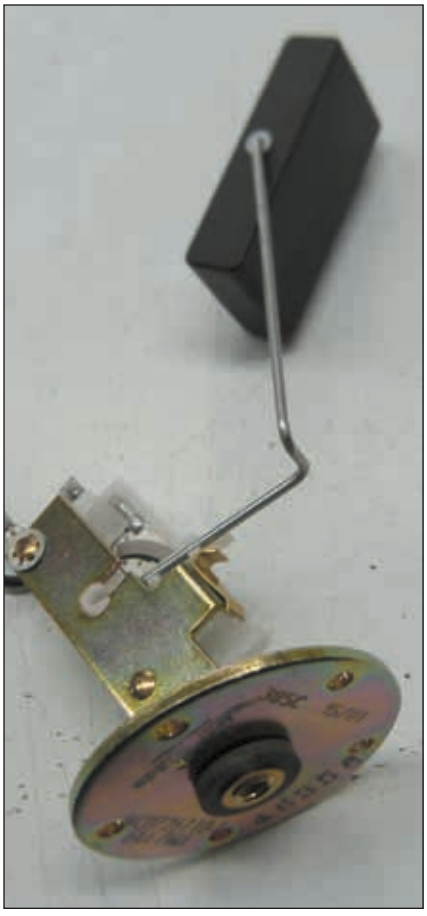
At many shops there's a tendency to keep the old senders in place and simply trying them when installing a new fuel quantity system. The trouble with that is the old fuel senders might not even allow the new instrument's software to pass the calibration portion of the setup. And it's a critical step in the installation.

Worth mentioning is that FAR 23.1337 partially says each fuel quantity indicator must be calibrated to read zero during level flight when the quantity of fuel remaining in the tank is equal to a type-specified unusable fuel supply. That could be a sizable amount. Unusable fuel isn't the same as empty, but it might as well be.

Shops are faced with the challenge of working with a wide variety of fuel sensors given the wide variety of aircraft that come into the hangar. Most of the earlier legacy systems (a tank sensor hooked up to an electrical gauge) used variable resistance to produce a value of measurement, with components scattered about the airframe.

As one example, Cessna mounted the gauges in the wing roots of very early models, but eventually went to panel-mounted gauges generally built by Stewart-Warner and Roch-

That's a digital fuel sensor made by CIES. In most applications it will be an accurate means of measuring fuel quantity for display on an aftermarket display like the Electronics International CGR-30P, bottom.



There is good reason to start with known good fuel senders. The Dynon Certified SkyView, top, compares the fuel quantity measured by the senders to what was metered by the flow transducer and warns of a mismatch. That's a new composite measuring float on a McFarlane sender. It replaces older Stewart Warner sensors.

ester, with some AC Delco units thrown in the mix. These companies have long retired from supporting the systems. Luckily, there is still at least some support for ancient systems.

A typical instrument shop might take in senders and indicators, but many simply send them out for repair or exchange. Before you give the go-ahead to have the system removed from the aircraft (expect considerable disassembly and downtime), make sure your shop knows what it is dealing with. It's possible that the sender or the gauge has once been replaced, which can lead to compatibility issued with replacement parts.

SHOULD YOU HAVE THEM REBUILT?

It could be worth a try—and we say that with caution. These things live hard lives and even an overhaul might not yield the accuracy you're looking for. As senders age, they accumulate dissimilar metal corrosion and rust due to condensation, wiper wear and residue buildup on the resistor. The wiper can also deteriorate.

Even experienced installers have jumped through hoops to have old senders rebuilt, only to find that they still didn't perform all that great when mated with the latest digital display.

"When we were installing the integrated G3X Touch in our Grumman Tiger (the STC airplane) we sent the original fuel senders out for overhaul and ultimately replaced them with digital CIES senders, which easily outperformed the rebuilt ones," said one Garmin engineer. But in some cases it's worth a try with the right place.

One popular supplier, McFarlane Aviation (www.mcfarlaneaviation.com), has new PMA replacements for Stewart-Warner senders for under $400 list, modern transmitters with ceramic plates printed with resistive ink. These have been tested to millions of cycles with no failure of the printed-on resistor element or the wiper. The potentiometer is faced with conductive bars that when contacted by the wiper provide a resistance proportionate with the wiper location, the location of the wiper controlled by the fuel level and float. Unlike wire-wound designs, the ceramic design might last forever.

Air Parts of Lock Haven (www.airpartsoflockhaven.com) was established in 1987 and is perhaps the most popular for rebuilding senders. Its sender rebuild prices start at under $200, plus parts, which could make for a reasonable alternative to the shotgun approach. And if you aren't installing a digital fuel display the company's gauge overhaul service starts at around $150 and it can support all three of the legacy brands, including Stewart-Warner, Rochester and AC Delco.

We like that much of Lock Haven's work involves exchanges simply to speed things along. After all, engine display projects take long enough. You and your shop don't need more delays as you wait for a shop to rebuild the original senders. It's well-staffed, with 12 technicians working on instruments each day. Turnaround is usually less than three weeks. It also has an extensive inventory of senders ready to ship because the company purchases as many cores as it can find.

GET WITH THE TIMES

The technology trend over the last few years has been a switch to digital senders and there are plenty of benefits. They're standard in a lot of OEM applications and the STC list for retrofit has exploded. Digital, magnetic senders like those made by OEM and aftermarket provider CIES Inc. (www.ciescorp.com) have

FUEL FLOW VERSUS FUEL QUANTITY

Some buyers confuse a digital fuel totalizer with a digital fuel quantity system (no matter if the fuel quantity display is standalone or built into a big-screen engine monitor). They're two different animals. The image at the top left is a JP Instruments FS-450 retrofit fuel computer, also known as a fuel totalizer. A misconception is that fuel totalizers measure fuel quantity. While that may ultimately be the end result and a good way to keep tabs on how much fuel is really remaining (you first have to enter the amount of fuel that is in the tanks), a fuel totalizer meters the amount of fuel that flows to the engine. Think in terms of fuel endurance (based on flow) rather than fuel quantity. Fuel metering is done with a fuel flow transducer installed in line and prior to the fuel distributor or carburetor. The fuel passes through a small axial turbine wheel and past an optical sensor located inside the transducer body, which spins faster at higher fuel flows and slower at lower ones. It converts the energy of the spinning turbine wheel to electronic signal pulses, which are passed along to a microprocessor and then displayed on a control head or on a GPS navigator (generally on a fuel endurance utility page).

Through third-party software, even entry-level totalizers can do a lot for real-world fuel planning. That's because integrating one with a modern GPS navigator can add serious and simplified trip planning, including the foolproof graphical display of endurance directly on the moving map. No more flipping to a fuel planning utility page on the navigator to know when you better start looking for gas.

digital signal outputs for fuel imbalance warnings, among other things. And even if a big-screen primary engine display with digital fuel quantity capability isn't on your must-have list, fuel quantity indicators have gotten modern.

As we've covered in previous reports, the Aerospace Logic FL202 series instrument is a modern fuel quantity display that fits in a 2-inch instrument cutout and, aside from the senders, is a one-piece system. The device is STC-approved as a primary fuel quantity gauge, has a 65,535-color LCD display and connects with the senders through a DB25 interface connector. The instrument is shown in the sidebar above (right photo).

But even when upgrading to a modern fuel quantity control head you'll likely have to also replace the senders with something more modern.

Aerospace Logic's STC requires the use of the CIES magnetoresistive digital fuel sensors. Magnetoresistive senders have more precision than old-school senders, plus they work well under extreme temperature fluctuations and are compatible with alternative fuels.

CIES makes bolt-in replacements for a variety of aircraft, including Cessna singles and twins—from the 150 to the 208 Caravan and a ton of models in between. There's also compatibility with a variety of Piper and Beech models.

The CIES senders do require a power wire, but they can also support a variety of modern fuel displays. This includes the popular JP Instruments EDM900/930/960 displays, some Electronic International displays, the defunct Auricle engine monitor and the Aerospace Logic head, as mentioned.

Last, before committing to a primary engine display system (and integrated avionics system that has fuel quantity display) ask the installing shop if the quote includes replacing or at least overhauling the senders. Chances are it does not and in our estimation this can end up costing more downtime at the end of the job. The better approach is to deal with it while the aircraft is opened up.

A replacement used spinner dome for a three-blade prop on a Beech Baron, shown here, can cost as much as $600.

Spinner Upkeep: More Than Aesthetics

Propeller spinners take the brunt of vibration and can be difficult to repair. There are limited but good aftermarket replacement options.

by Jim Cavanagh

About the only time we pay much attention to propeller spinners is when cleaning the bugs off, and hopefully at the annual inspection. Truth is, spinners are one of the most overlooked parts on the airplane because they're generally trouble-free. It's an accessory that is always there (although they can depart the airplane), subtly adding to the look of your aircraft and frankly, as something pointy out front where it pierces the air and helps the plane get the most speed, engine cooling and power.

But at some point, you might be faced with spinner maintenance or replacement. For this short article I did some research to see what options there are. Herewith is a report.

SPINNER TECH 101

Spinners have been around since the early 1900s. Tractor aircraft used radial engines for saving weight (mainly due to their small crankshafts), and the spinner fitted over the propeller to smooth the airflow into the cowling and fair out the prop hub. Some prop hubs on the carved props were quite large.

When aircraft transitioned to inline or opposed engines, spinners weren't initially considered necessary, but for decoration someone developed the Skull Cap spinner that simply covered the prop bolt heads. You'll see these on Cubs, Champs, Vagabonds and the like.

For larger planes, spinners were developed that covered the entire prop hub. The dome comes with a couple of bulkheads; the larger bulkhead slipped on over the prop attach bushings, the prop was mounted and then the smaller front bulkhead is installed, through which all of the bolts ran. The bulkheads and the prop have to be keyed so that the prop would be at the 10 o'clock position when stopped. One of the prop bushings and one hole in all other parts are slightly larger to facilitate this.

Naturally, the prop bolts must be safety wired, and this is one item on the annual inspection—checking torque and replacing new safety wire. On wooden props this must be done around every 50 hours or with a seasonal change.

While we're at it, it's worth a review on prop positioning. The prop has to be "keyed" to this 10 o'clock position to facilitate hand-propping the aircraft. Many early aircraft had no electrical system or starter. Even planes with starters often had to be hand-propped for one reason or another. The 10 o'clock spot puts the number one cylinder at top dead center, the spot where the mags are referenced when timing them. On small engines, a simple flip of the blade usually starts the engine in an instant. I witnessed this firsthand recently at Jack Brown's Seaplane Base in Florida, where its fleet of Piper J3 Cubs on floats have no starters. The instructor or an employee hangs off the float, flips the prop and the little engine lights on the first try almost every time.

SPINNER MAINTENANCE

Spinners for larger aircraft that use constant speed or other props are rather intricate, with the rear bulkhead bolted to the prop hub itself in some cases. All prop manufacturers have maintenance requirements for their products and these can be involved and are mostly for mechanics. Manufacturers also provide propeller logbooks and it's here where you might find work done to the spinner.

An aircraft owner doesn't have to do very much to keep the spinner maintained. And anything he or she does is pretty basic. You keep it clean, inspect it for cracks at the prop holes, look for cracks and elongated holes at the mounting screws and have the prop inspected at the correct intervals and overhauled at TBO, per the manufacturer specs. An owner can and should remove the spinner and can inspect/replace the safety wire on the prop bolts, according to a couple

of things in the FAA's Approved Owner Maintenance List Part 43, Appendix A, Paragraph C.

It is legal to remove a fairing, which technically is the aerodynamic definition of a spinner, and it is part of the cowling—which is also repairable under Part 43. The owner cannot install the prop or check torque.

Realize that spinners are tough enough to take a lot of the stress caused by the engine and airplane, but they are relatively fragile if you drop one, and difficult to repair if the damage is significant. They suffer from engine and ignition impulses and vibration, plus they can suffer from corrosion if they sit ignored. Loose prop bolts in holes that have elongated, and loose or overtorqued attachment screws, can cause damage.

By their nature, the process used to manufacture a spinner makes it strong. Starting with a ductile aluminum like 3003/T14, a flat plate of aluminum is spun at significant speed while chucked into a metal spinning lathe. Different thicknesses are used depending on the size of the spinner. An "iron" is then pressed into the aluminum sheet, causing it to flow onto a turning "chuck," which is the shape the manufacturer requires. This realigns the metal matrix and balances the dome.

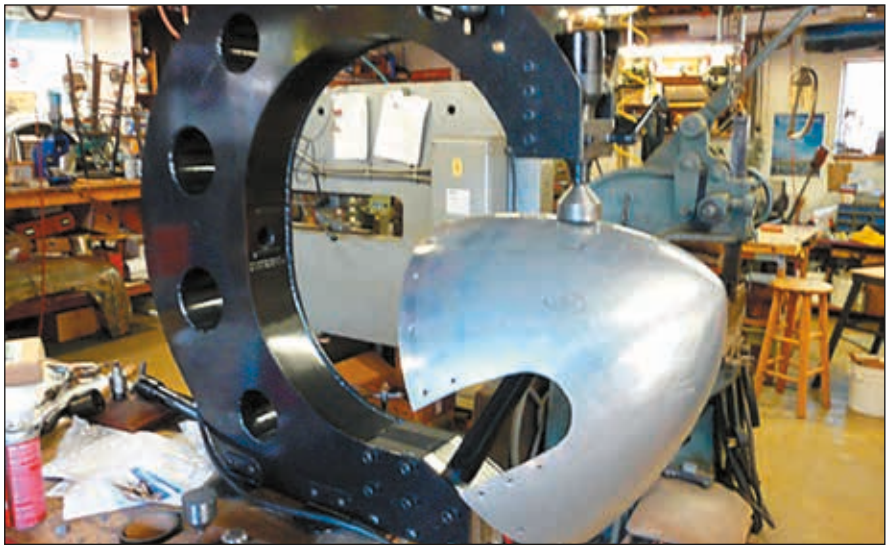
Adding the front bulkhead further strengthens the spinner. Some front bulkheads are permanently attached to the dome. Others attach to the prop hub and are secured to the dome with screws, while some domes are press-fitted onto a bulkhead fastened to or secured by the propeller.

To the letter of the law, it is perfectly legal to disassemble anything on an airplane; as an owner you just cannot reassemble certain things. If you want to take the spinner, bulkheads and prop off to inspect them (say you felt a vibration and are trying to track it down), go right ahead. Most of the time, you can see damage without disassembly, but if you buy an airplane from a DIY owner who may have installed it himself, you may want to take a look at all of it—closely. What might you see?

Cracks are the most common damage, and usually these are at a screw hole or in the attachment bulkhead. School is out on whether you can repair a spinner or bulkhead by welding it. In my research, I found that a couple of companies say that they have certified repairs for this. These are not cheap repairs because the bulkheads themselves are more expensive than you would imagine.

One thing I would not do is stop-drill a hole in a spinner and fly the aircraft. I tried it—and I watched the spinner fly up over my windshield never to be seen again. I was young and dumb and had just read about stop-drilling cracks in aluminum. We dodge many bullets in life.

The vibration that can cause damage could be eliminated with a dynamic balance. Almost every shop can do this these days. This balances the propeller, hub and spinner assembly along with any crankshaft or powertrain vagaries. A dynamic balance exists when the entire assembly (a rotating system of mass, including everything that turns with an aircraft engine) is balanced while in motion and no centrifugal force is created. Turbine-like smoothness can be achieved.



Kent White ("The Tin Man" from TM Technologies) was able to repair this severely dented spinner from a Stearman.

REPAIRS

A dented spinner may or not be repairable. I have used suction cups and even hot melt glue, like

Colorado-based Univair (Univair.com) sells a spinner dome that fits a Cessna Skyhawk for $466. The bulkhead is $265. The spinner bulkead positioned to the right in the lower photo is replaced by a composite bulkhead by TCB Composite. A bulkhead mounted on a four-blade prop on a Cirrus, bottom.

the paintless dent guys do. Some manufacturers tell you to replace a spinner if an attached bulkhead is damaged. Some dents might need to have the spinner annealed, hammered out or planished to reshape, but it takes a good metal worker to do this.

The second most common damage is purely a result of maintenance. This is attachment screw holes that become distorted. Some are tightened so much that they distort the dome metal around the hole. This causes stress risers that could turn into cracks. A trick is to weld the screw holes shut, planish to flatten them and then redrill.

To avoid crushing the metal and scratching paint, use a nylon washer, then a stainless steel washer and then a stainless steel screw. These are not a structural location so stainless steel is legal here. It is important to set your electric screwdriver to a torque that will not distort the screw head and bear down solidly, or simply torque the screws by hand.

A spinner left on an airplane for long periods of time could develop corrosion that appears as a rash under the paint. The paint will flake off and the corrosion presents as a white powder. Some manufacturers want you to replace the part if corroded, but you might strip the paint, treat the corrosion and sand it smooth. If the corrosion is minimal, you might get by without any action, but check with the manufacturer or IA to be sure.

If you need to replace your spinner for whatever reason, perhaps if you want a shiny chrome spinner, they are available from the manufacturer with a few aftermarket outlets. You can even polish your spinner if you want to do the work. Composite spinners are getting popular. TCB Composite (www.tcbcomposite.com) makes composite spinners and bulkheads for Cessna, Piper and Grumman. When first introduced years ago, composite spinners got a bad rap, but TCB has perfected and certified their parts. They also have a source for having the spinner chromed. There is usually one at its airshow booths. The end result is impressive and costs significantly less (nearly 80 percent) than an OEM spinner replacement.

In general it's rare that a spinner has to be replaced, but sometimes it's unavoidable. An engine upgrade might require a three-blade prop and that of course requires a different spinner. A lot of mods shops have shelves of spinners on hand so ask if they have one that works for your application. Keeping your spinner clean and doing the regular inspections—especially when you think you feel a new vibration—may help you avoid replacing it.

Alpha Electro: One Fish, Small Pond

Surprisingly, even though hobbled by lagging regulation, Pipistrel is still building and selling an improved electric trainer. We found it fun to fly.

by Paul Bertorelli

For all the blather about electric airplanes, you'd think by now there would be at least three or four to pick from and compare. But no, except for electric motorgliders, there's only one commercially available electric airplane, Pipistrel's Alpha Electro.

Despite the lack of a refined regulatory framework, Pipistrel is finding buyers for the Electro around the world, although not in large volume. But between Electro sales, legacy gasoline models and an aspirational urban air mobility market, Pipistrel recently opened a new factory in Gorizia, Italy, just across the border from its headquarters in Slovenia. The new facility is large and has vastly more capacity then it's using now. When I visited in May 2019, the company was building as many as five Electros a month.

COMMITTED TO ELECTRIC

Pipistrel founder Ivo Boscarol is an electric airplane fundamentalist, but even he admits the Electro was a long shot project. It evolved from the Alpha trainer, which is itself an iteration of the Virus, a popular seller for Pipistrel. Both versions of the Alpha are entirely composite, but it uses a single-skin laminate rather than the honeycomb layup found in the Virus. That makes it easier to repair in the field.

All of Pipistrel's aircraft spring from glider DNA and are equipped with high-aspect ratio wings that are quickly detachable. While Pipistrel said the right way to do an electric airplane is with a purpose-built airframe, the Alpha's low weight and low drag made it suitable if not ideal for conversion to electric.

That conversion was called the WATTsUp and first appeared in 2014 as a proof of concept. I flew an early production version of the airplane on a visit to Slovenia in 2015. In the four years hence, Pipistrel has improved the aircraft with slightly higher capacity batteries, improved battery monitoring systems, different props and other minor improvements that make it feel more refined. Batteries continue to be the electric airplane's limiting weak point and not just energy density, but in-service longevity. Pipistrel uses lithium-polymer chemistry which, although not the most energetic, provides the best combination of capacity and safety against fire risk. Allowing for the enclosures and management systems with five percent a year energy density gains, Pipistrel says it's approaching 200 wh/kg. That makes a slight dent in flight endurance, but not yet enough to make the airplanes disruptive of gasoline-powered models. And Pipistrel doesn't pretend otherwise, suggesting that schools serious about training buy an electric Alpha along with two gasoline models for longer training flights and cross-country work.

About 60 Alpha Electros, left, have been delivered around the world.

Pipistrel told me that the fleet leader Electro has under 300 hours, so battery service longevity remains laboratory estimates. For now, the company believes the aircraft will require two battery replacements per 2000 hours, the cost of which will be similar to overhauling a Rotax.

BATTERY LONGEVITY

While the Electro I flew was improved over the version I tried in 2015, the next-generation airplane—which will be certified under CS23—will have yet better batteries that will be water cooled for both discharge and recharge. Boscarol says this may double the effective battery life and if it does, it would significantly improve operating economics, knocking as much as $5 per hour off battery replacement costs. For the time being, early operational history shows that the equivalent "fuel cost" to operate an Electro is $3 to $5 per charge, variable with local kilowatt hour charges.

Operational experience also shows that a good rule of thumb is one minute of charging for every minute of flight and that it's neither necessary to charge the batteries fully nor desirable to deplete them below about 20 percent of full capacity. This argues for a typical training flight of about 50 minutes, landing with 15 or 20 minutes in reserve, followed by 50 minutes of charging. The water-cooled system may charge more quickly.

My impression of my first Electro flight in 2015 was somewhat colored by turbulent flight condi-

tions that masked both the aircraft's noise signature and smooth power delivery. It was dead calm for my flight in the newest version.

It's a little unnerving to have so little to do before takeoff. The master switch comes on, the battery condition is checked and then you can taxi to the runway and take off without warmup or setting anything else, other than trim and flaps.

While you're waiting for traffic, the engine is stopped. Yeah, I know. It's a motor, but in the electric airplane biz, it's called an engine for reasons that aren't apparent to me. Pipistrel started out with a Siemens engine but is now using its own purpose-built 50-kW (67-HP) motor, plus its own controller hardware.

Power application is through a single lever and the onset is indistinguishable from the gasoline model and not the silent whir you might expect of an electric airplane. There's no exhaust note, of course, but there's still prop and slipstream noise against the windshield. In flight, it's a different matter. On a glass-smooth morning with the power set to cruise at a typical 80 knots, the Electro is utterly vibrationless—again, no power or exhaust pulses—and quiet enough in the cabin to converse without extraordinary effort.

ECONOMICS ELUSIVE

The base price of an Electro is $142,000, plus between $7400 and $15,800 for a ground charging station, depending on voltage and charging rate desired. All in, that makes it at least $50,000 more than the gasoline version. Because regulations haven't caught up, using an electric airplane for training in the U.S. is a non-starter for now and with gasoline at $5 or less, the economics for the Electro are still not compelling. Pipistrel's long-term plan is that the regs will catch up and so will the operating costs, so it will continue to trickle Electros from the new factory.

View from the Alpha Electro cockpit, above, is expansive. Right panel is dominated by a Pipistrel-designed battery and energy monitor.

DAHER'S HYBRID-ELECTRIC TBM POC

Does the world need a seven-engine TBM? Probably not, but in announcing its own electric airplane project in June, Daher is taking no chances. In a joint project with Safran and Airbus, the company will use a TBM airframe as a test bed for a hybrid electric drive. For Daher, it's a second marriage with Airbus. Recall the two companies announced a cooperative agreement in 2014 to develop the E-FAN 2.0 and 4.0, with production aggressively planned for 2017. Never happened. As suddenly as it had entered the electric market, Airbus exited, dropping the E-FAN as a dead end. It remains involved in the E-FAN X project to develop a hybrid-electric airliner, plus designs for the aspirational urban air mobility market.

But even the E-FAN X project was roiled in June when Siemens announced that it was selling its aircraft electric motor division to Rolls-Royce. Along with Airbus, Siemens had been a partner in the E-FAN development and a major driver in electric aircraft in general. Some may be wondering if Siemens was signaling a lack of confidence.

For the TBM hybrid electric, the distributed electric power system, called EcoPulse, will be done by Safran while Airbus will provide aerodynamic expertise and batteries and Daher will presumably furnish the airframe.

EcoPulse is a developmental project sponsored by the French Civil Research Council with support from DGAC, France's Civil Aviation Authority. Repeating the ambitious timeline it announced for the aborted E-FAN project, Airbus says the first flight of the system is planned for 2022.

As currently configured, it has six tractor electric motors—three on each wing—a combined turbine and power generator. The aircraft is intended as a proof of concept.

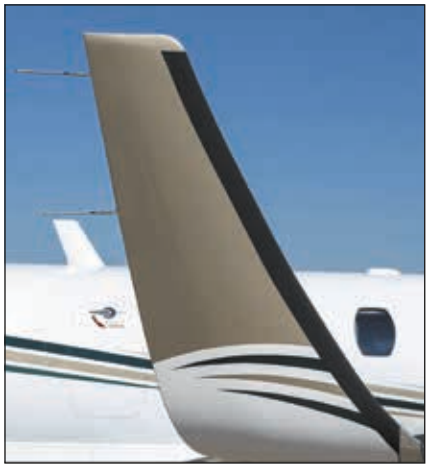
Got Spot? FAA: Check GPS, ADS-B

The FAA says that Spot satellite messengers cause interference with GPS signals. In other news, FAA grounds Tamarack active winglet-modded jets.

by Larry Anglisano

If you fly with a Spot portable satellite messenger, use caution when placing the device around GPS receivers and antennas. In an Information for Operators publication (InFO 19006, May 6, 2019) the FAA advises that it has been notified of "several instances of intermittent loss of GPS position information" when Spot messengers are used in the cabin. It also noted that the signal problem could also affect ADS-B systems. In the FAA InFO letter, the agency reiterated that it was aircraft operators who confirmed the use of Spot PED as the cause of the GPS interference.

Worth mentioning is we've flown with several models of Spot messengers, including the SpotX for a flight trial in the October 2018 *Aviation Consumer*, and didn't notice any interference problems. However, several Spot users recently told us they experienced total GPS signal loss from panel-mounted Garmin GNS- and GTN-series navigators (connected to ADS-B transponders). Two of these were in Aviat Husky aircraft, particularly when the device was positioned in the rear of the cabin.



The FAA's InFO publication said the company is "cooperating with the FAA to provide detailed information to existing and future customers regarding the safe use of Spot PEDs during aircraft operations." This includes updating user's guides and email notifications.

The company currently advises to keep the devices at least 12 inches from GPS systems and to test for interference by putting the devices in Tracking mode. If it interferes, move it to another location or turn it off.

This is precisely why the FAA has Advisory Circular 91.21-1D, which addresses the use of personal electronic devices aboard aircraft. Given the number of portable devices we use in flight, the FAA AC is worth a review, while paying close attention to interference created by a Spot.

TAMARACK WINGLETS

This issue is a bit more serious, and enough for the FAA to issue an Airworthiness Directive (AD 2019-08-13) that grounds Cessna CitationJet 525, 525A and 525B models equipped with the aftermarket Tamarack ATLAS (active technology load alleviation system) winglets.

Even as they add lift, winglets impose additional structural loads on the wing that can exceed its certification limits. The solution from Tamarack Aerospace is to pair winglets with an adjacent control surface (one on each wing) that act as an automated aileron, requiring no pilot input. A network of sensors constantly monitors wing loading

in all phases of flight and when loading is approaching design limits for the wing structure a spoiler instantly deploys, dumping the lift and relieving the wing structure of any potential overload. On the Citation the wings get an additional five feet of total length. The ATLAS is installed on the trailing edge of the added section of wing. The end result is better fuel efficiency because of higher climb rates to altitude.

But five incidents of uncommanded roll events with the ATLAS activated was enough for the FAA to issue the AD for Citations. There's also an ongoing investigation of a fatal ATLAS-equipped CitationJet accident. The ATLAS was introduced in 2015 after flying on Cirrus SR22 models for the eventual STC on Citations.

In an interview with sister publication *AVweb*, Tamarack's Jacob Klinginsmith said the company was aware of the problem and already developed a hardware kit to address inadvertent, asymmetric deployments of the system. The failure mode, according to Klinginsmith, was related to a small screw inside the actuator assembly that would fall out and short, ultimately moving the actuator. At press time most of the aircraft have been upgraded. While the FAA's grounding put Tamarack into bankruptcy, the company is reorganizing to support the modified aircraft.

Mooney 231/252:

The turbocharged M20K is a major step up in performance and complexity over the M20J.

These days there is considerable demand for turbocharging, evident by the sales of the Cirrus SR22T—a model that continues to outsell the normally aspirated SR22. Boy, have times changed. Flash back nearly 40 years when Mooney's M20K arrived in the GA market during a time when turbocharging was relatively new and the demand for high-flying aircraft was different than now.

The M20K wasn't exactly a slam dunk. Mooney didn't get the airplane's turbocharging system right on the first try and the model developed a reputation as a maintenance hog. At this point that reputation has been mostly burnished and the fact that the M20K bores along between 160 and 200 knots on relatively little fuel has boosted the model's used price. But that turbocharged engine can still be a maintenance hog.

The cabin is small and with a single door, can be hard to get into. But it's a Mooney—and its owners love them—because there is a lot of performance to love. If cruising fast yet miserly is your goal, the M20K models—the 231, the 252 and the Encore—are worth a serious look.

HISTORY LESSON

Mooney came into the turbocharging game relatively late compared to other manufacturers. In 1966, Cessna pioneered the market with the T210 and made a strong showing in the single-engine, high-altitude market. Beech brought out the V35TC in 1966, but it was never as strong a seller as the A36. Mooney wasn't completely flat-footed during the 1960s, introducing the 310-HP M22 Mustang in 1967, a big brute of an airplane that was as ugly as it was unsuccessful.

Mooneys are fast and efficient because they have low-drag airframes with a small frontal area.

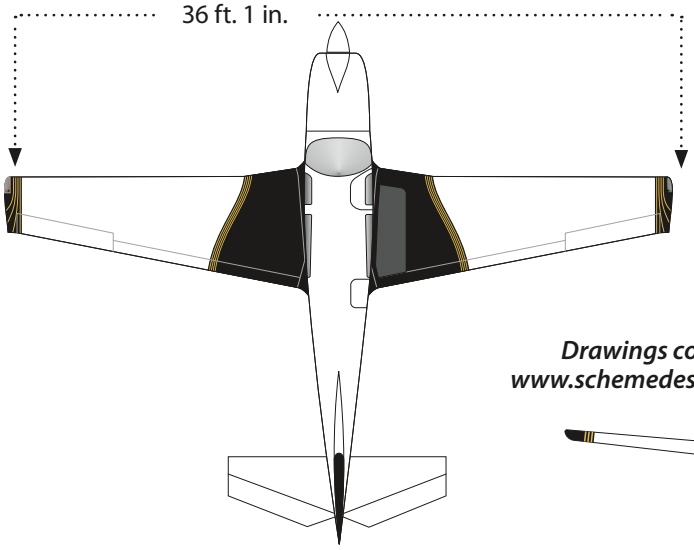
Through the 1970s, Mooney did well with efficient airplanes powered by Lycoming four-bangers. Mooney's big breakthrough came in 1977, when the M20J 201 was introduced as the fruit of a clever Roy LoPresti-led aerodynamic cleanup of the venerable F-model. The 201—named for its maximum speed in miles per hour—marked a turning point for Mooney, even if the claimed speed was somewhat optimistic.

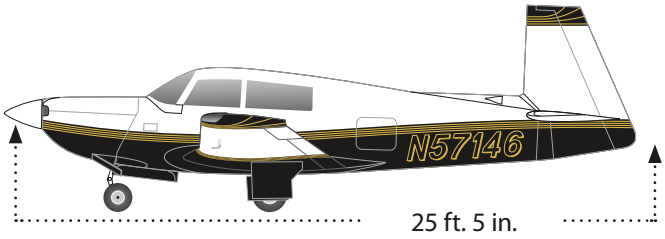
As early as 1977, Piper had the Turbo Arrow and Mooney realized it needed to compete in this market. The result appeared in 1979 as the 231—again, named for its top speed—or M20K. It was essentially a 201 with a six-cylinder, 210-HP Continental TSIO-360-GB in place of the 201's 200-HP Lycoming IO-360. The airframe had a lot going for it. It was strongly built of welded 4130 steel, the gear system was all but indestructible and the handling was mannerly, easily flown by a pilot with minimal retract experience. By modern standards, Mooney had a smash hit on its hands. It sold 246 airplanes the first year, outdistancing the 201 by nearly two to one. The fact that the two airplanes were so similar simplified the build process and likely made the project profitable from the first year.

The differences are in minor aerodynamic refinements. The K-model's fuel capacity is 10 gallons

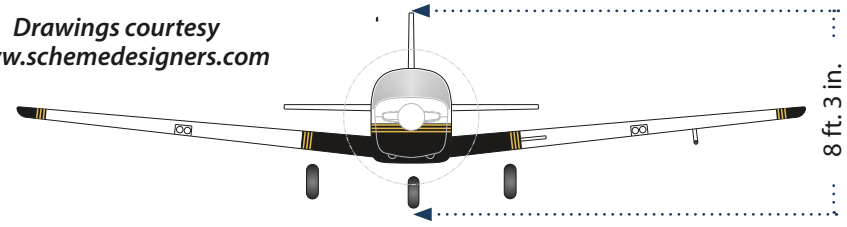
That's a 1979 M20K cruising in the lead photo. In Mooney tradition, the 231 has sturdy, predictable and accurate handling, but expect the controls to be heavy in pitch and roll.

MOONEY 231/252





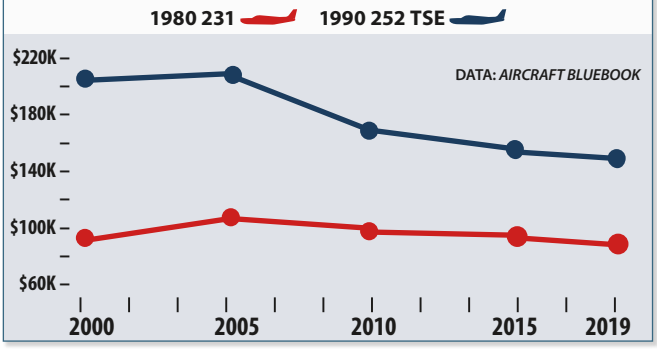
Drawings courtesy
www.schemedesigners.com



MOONEY 231/252 MODEL HISTORY

MODEL YEAR	ENGINE	TBO	OVERHAUL	FUEL	USEFUL LOAD	CRUISE	TYPICAL RETAIL
1979-1980 231 (M20K)	210-HP TCM TSIO-360-GB	1800	$40,000	75	1100	191 KTS	±$83,000
1981-1983 231 (M20K)	210-HP TCM TSIO-360-GB	1800	$40,000	75	1100	191 KTS	±$86,000
1984-1985 231 (M20K)	210-HP TCM TSIO-360-LB1B	1800	$40,000	75	1100	191 KTS	±$98,000
1985 231 L/M (M20K)	210-HP TCM TSIO-360-LB1B	1800	$40,000	75	1100	191 KTS	±$74,000
1986-1987 252TSE (M20K)	210-HP TCM TSIO-360-MB1	1800	$40,000	75	1100	201 KTS	±$125,000
1988-1989 252TSE (M20K)	210-HP TCM TSIO-360-MB1	1800	$40,000	75	1100	201 KTS	±$145,000
1990 252TSE (M20K)	210-HP TCM TSIO-360-MB1	1800	$40,000	75	1100	201 KTS	±$160,000
1997-1998 M20K ENCORE	220-HP TCM TSIO-360-SB	1800	$45,000	80	1100	197 KTS	±$225,000

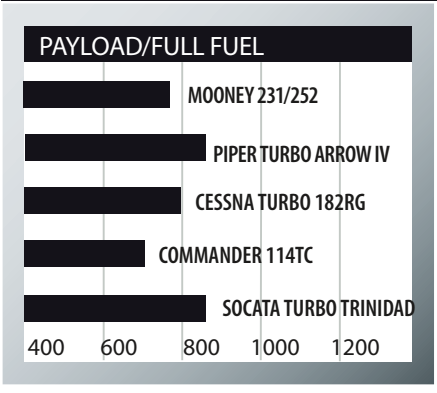
MOONEY 231/252 RESALE VALUES

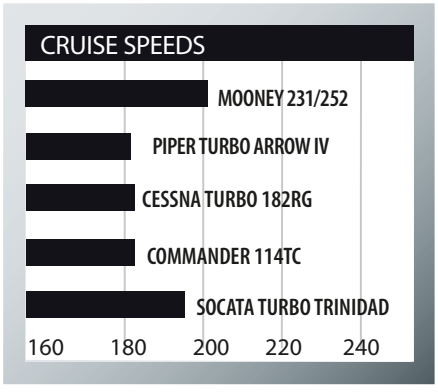


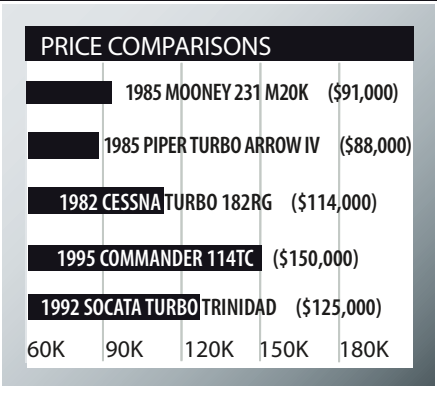
SELECT HISTORICAL ADs

AD 2009-24-52	INSPECT/REPLACE RECENTLY INSTALLED HYDRAULIC VALVE LIFTERS
AD 98-24-11	INSPECT AILERON CONTROL LINKS FOR GUSSET OR CRACKS
AD 98-21-26	INSPECT MAIN LANDING GEAR LEG BRACKET FOR CRACKS
AD 95-17-06	INSPECT ROCKET CONVERSION EXHAUST AND TURBO MOUNT FOR CRACKS

SELECT LATE-MODEL COMPARISONS







A lot of M20K models we found on the used market still sport round gauges and a variety of retrofit avionics, top, while some have been completely done over in modern glass flight displays, electronic engine displays and touchscreen navigators like the panel in the bottom photo completed by Chief Aircraft.

more than the J-model, and both empty and gross weights are 160 pounds higher. Design-wise, the 231 was exactly what the buyers were looking for: a turbocharged 201.

But if buyers were hoping for the 201's excellent dispatch rate, they got something less. Problems with the 231's Continental engine were several-fold and hurt the model's initial reputation. The new cowling didn't cool the engine adequately; the fixed-wastegate turbo required constant attention and was easy to mismanage; overboosting and high heat put undue stress on the engine; and it was prone to cracking cylinders and cases. The connecting rods were prone to failure and the original magnetos were unpressurized, and would arc at high altitude. On top of all this, the TBO of the first engines was a miserly 1400 hours, later upped to 1800 hours, where it still stands. Even with all these faults—and they were considerable—some owners achieved impressive maintenance reliability by obsessive attention to operating technique. Specifically, that meant careful leaning and attention to cowl flaps and preventive maintenance of the turbo. But not all owners were so careful and premature engine crumps were common.

MAKING IT BETTER

With a couple of years of experience under its belt, Mooney undertook some improvements, adding a split rear cargo seat in 1982, while in 1984, a new variant of the engine—the LB1B, which is approved as a replacement for the GB—was introduced with better cooling and overboost protection. Mooney also included some aerodynamic tweaks that added 3 to 5 knots: sealed nosegear doors, a belly pan, a more streamlined tailcone and removal of one of the vent intakes. The alternate air intake system changed to address reports of icing-induced power loss.

While these fixes certainly helped, the improvements were hardly night and day. By 1986, further retooling produced the 252TSE for Turbo Special Edition. The 252, while still an M20K, is significantly different from the 231. Another variant of the engine was fitted, the -MB1. The induction and cooling systems were reworked and a new intercooled, density-controlled, variable wastegate AiResearch turbocharger replaced the original, fixed wastegate Rajay/Rotomaster unit. Other changes included infinitely adjustable electric cowl flaps to replace the original dual manual flaps. There was a vernier throttle control, more elbow room and new-look radiused windows.

The 231's original 60-amp, 14-volt electrical system was upgraded to a 70-amp, 28-volt system. This was much needed, since a fully loaded K-model could max out the electrics long before the days of moving maps. An electrically driven backup vacuum pump was made standard equipment.

The 252 also got further aerodynamic tweaking in the form of gear doors that fully enclose the wheels when retracted and cover the wells when the gear is extended. The 252 also got an increase in gear-extension speed to 140 knots, up from 132 knots. Maximum speed with gear extended is 165 knots for the 252.

In all, 889 231s were produced between its introduction in 1979 and 1985. The 252, introduced in the middle of the GA slump of the 1980s, is less numerous. Production totaled, ironically, 231 airplanes. The K-model made a brief resurgence in 1997 as the Encore,

To ingress the cabin, you sort of slide down into the seats of any Mooney and the 231/252 is no exception. You won't load large items through the rear baggage hatch, bottom, but the 120-pound storage capacity is more than adequate.

when Mooney was going through yet another of its many reorganizations. But it was not to be and the model was dropped again in 1998. Meanwhile, the so-called long-body models, specifically the M20M TLS and later the M20R Ovation and Acclaim, eventually came to dominate the Mooney line.

PERFORMANCE

The K-model lives in a league of its own when measured against the narrow market segment of four-place, turbo retractables. At cruise, the 231 outstrips its competitors—the turbo Arrow, the 182 RG and Commander TC—by roughly 20 knots, despite the fact that the 231 MPH (196 knots) top speed isn't reachable under real-world conditions and probably at all.

Realistic max cruise is about 190 knots for the 231, but 170 to 175 knots is more like it. The 252 is about 10 knots faster, thanks to intercooling. Both M20Ks win the altitude battle as well, with a maximum operating altitude of 24,000 feet for the 231 and 28,000 feet for the 252, versus 20,000 feet for the Cessna and Piper. The Mooneys outclimb the others by about 150 FPM.

Due to physiological considerations, however, high teens to low 20s are the airplane's best envelope. At lower altitudes, turbocharged airplanes aren't much faster than their normally aspirated siblings. In fact, the 231 is actually slower than the 201 below 8000 feet, due to cooling drag. The J-model will also outclimb the K-model below 8000 feet.

Many owners operate 252s conservatively. One owner told us that 65 percent power yields 170 knots at 10,000 feet and 200 knots at FL210, burning 11.5 GPH. The 231's numbers are proportionately lower at high altitudes, although the difference lessens the lower one goes.

With 75.6 gallons of usable fuel, the 252 can climb to FL280 and operate a total of 4.9 hours, or just under 990 nautical miles still-air range with reserves. The 231 has comparable range and endurance, but can't fly as high.

231 VERSUS 252

The improved powerplant installation makes for a significant operational difference between the 231 and 252. The engine still produces 210 HP, but it does so at a markedly lower manifold pressure: 36 inches for the 252 versus 40 inches for the 231, thanks to the improvements in the tuned induction, cooling and turbo systems.

The 252's induction and cooling air intakes are separate from one another. Induction air enters through a NACA scoop on the side of the cowling, is turned 90 degrees to minimize induction icing through inertial separation and passes through a larger, less-restrictive air filter. It's then compressed and run through a 42-square-inch intercooler.

The result is dramatically lower temperatures for the induction air, from 60 degrees F at lower altitudes to 120 degrees F up high. That means more power at higher altitudes and a wider detonation margin. The 231's critical altitude

MOONEY M20K MISHAPS: ENGINE

The first thing that struck us in our review of the 100 most recent Mooney M20K accidents was the virtual absence of runway loss of control (RLOC) events. We found only three pilots who lost control of the airplane during rollout—a startlingly low number and impressive evidence of the good ground handling of the Mooney 231 and 252 series airplanes.

Overall, we observed a lower landing-related rate of accidents than we expect for a high-performance, nosewheel airplane. Eight pilots either hit hard or set up a pilot-induced oscillation after touchdown and damaged their airplanes. A few pilots managed to get the airplane sideways to the runway, initiate a go-around and then either hit something on climbout or stick a wingtip into an obstruction—although at a rate less than we expect to see.

The fuel-related accident rate was about average for airplanes where the pilot has to keep track of fuel in two tanks. The majority of the 14 accidents involved simply running out of fuel; however, there were three accidents in which the pilot ran a tank dry and didn't switch to the other tank—which had plenty of fuel. One pilot somehow selected the "off" position just prior to takeoff and one put the selector between tanks.

We somehow feel for the pilot who put his airplane in the shop to have one fuel tank resealed. When he got it back, it had only a small amount of fuel in that tank. You guessed it—that's the tank he selected for takeoff. He never did move the selector to the fuller tank before returning to earth.

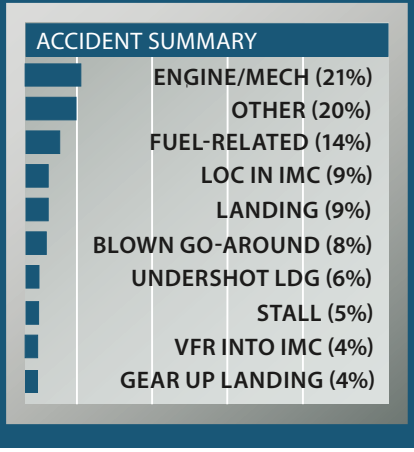
Water contamination brought down three airplanes; one had not been flown in years and the owner resisted a maintenance technician's offer to fully drain the tanks when the owner kept getting water in his fuel samples prior to start up. One pilot knew he had some water in the system but couldn't seem to get it all drained. He took off anyway and climbed high into sub-zero temperatures. He came back down when the water in the system froze and stopped fuel flow.

There were 21 engine power loss events. In about half of the accidents, the post-crash evaluation could not determine why the engine wouldn't reciprocate. The vast majority of the remainder were due to improper or neglected maintenance.

Mooneys are slippery, so we were on the lookout for accidents involving loss of control resulting in a diving spiral and inflight breakup. We saw none that resulted in airframe separation, although one pilot, upon emerging from the clouds in a diving spiral, pulled so hard that he bent the airframe.

The same couldn't be said for the IFR pilot smoking along in IMC who decided to descend to the altitude to which he'd been cleared by stuffing the nose down far enough to take the airplane well past Vne. The elevators went into flutter and departed, inducing an inflight breakup.

The M20K is not a short-field airplane. One owner/mechanic discovered that after he made a forced landing following engine problems. He fixed the engine and tried to take off. Belatedly realizing there wasn't enough room, he aborted but slid into the trees at the end of the field.



is only 14,000 feet, while the 252's critical altitude is 24,000 feet. In practical terms, this means that the 252 can continue to climb at about 1000 FPM into the mid-20s, can fly higher and is faster once up there.

The most important difference between the 231 and 252 lies in engine management. The revised powerplant installation in the 252 made an enormous difference and makes the 252 a more desirable airplane. Because the 231 has a fixed wastegate, the pilot must constantly monitor manifold pressure and fiddle with the throttle to keep it within limits. Bootstrapping and overboosting are constant worries. Thanks to its automatic wastegate, the 252 doesn't suffer these foibles.

HANDLING

The 231/252 series handle like typical Mooneys: relatively heavy in roll and pitch, with good stability. The K-models have greater pitch authority, thanks to a slightly larger elevator, and the longer engine makes it somewhat nose heavy. That can make flaring a challenge with a forward CG, but nothing like, say, a Cessna 182.

Pitch change with gear extension/retraction is slight, but flap extension produces a nose-down moment. Transition from full flaps to trimmed for go-around takes heavy pressure on the yoke and fast action on the trim. Using the electric trim, anticipation of configuration changes helps reduce pilot effort.

Speed control is essential when approaching and landing any Mooney. Approach too fast and the K-model will float. Try to plant it on the ground and it will fight back, porpoising vigorously and striking the prop if uncorrected. This is a common accident for all Mooneys, not just the K-model.

Because of its ability to fly fast, some owners say the best addition ever devised for Mooneys is speedbrakes. These are especially useful for the 231, which doesn't have the 252's higher gear limits. (Speedbrakes are standard on 252s.)

Ground handling isn't great. The airplane is low slung and the Mooney's stretched-out seating position hinders visibility on the ground. It also makes gaining purchase on the brakes difficult.

With new paint, a new leather interior and major avionics upgrades, reader Bill Pearson says his 252MSE is better than a new Mooney, but has a terrible useful load.

The wingspan (36 feet, 1 inch), combined with the wide turning radius of 41 feet, makes negotiating a crowded ramp challenging. One other caution: Many Mooneys suffer damage to the nosegear trunion when towing turn limits are exceeded via power towing. Owners learn to watch the ramp rats carefully.

CABIN, PAYLOAD

On paper, the 231 and 252 have the same loading characteristics. In reality, however, the typical 252 weighs more, simply because it has more equipment. Neither airplane is a stellar load-hauler. Gross weight is 2900 pounds and basic empty weight is 1800 pounds, usually more. Real-world, full-fuel payloads are on the order of 400 to 500 pounds, making the M20K a useful two-place airplane, with generous baggage. Thanks to its fuel efficiency and good endurance, however, there's flexibility built into the load-carrying equation.

The latest M20K, the Encore, has about 200 pounds of additional load, thanks to beefed-up landing gear. Staying within the CG is easy and there's no worry of aft-tending CG as fuel is burned off.

The baggage compartment is large, with a capacity of 120 pounds, although the high sill door makes it difficult to wrestle large objects into the airplane. Baggage capacity can be increased by folding the rear seatbacks down together or individually.

Mooneys are fast and efficient because they have low-drag airframes with a small frontal area. That translates into cramped quarters. The seating position is quite different from that of most airplanes. It's more of a sports-car posture than an upright seating regime. There's plenty of legroom fore-and-aft, but less lateral room. Those of below-average height may find that they can't reach the rudder pedals without a booster cushion behind their backs or pedal extensions.

Early Mooneys tended to be spartan in interior arrangements. But by the time the 231/252 appeared, Mooney recognized the need for more modern if not luxurious appointments. Thanks to a bit more elbow room and somewhat plusher finish, the 252 is arguably more comfortable than the 231. The 252 is also quieter and many feel it's the quietest of all Mooneys, thanks in part to the induction system and the fact that things quiet down the higher you fly.

The panel layout is quite good, with one seemingly obvious feature that has probably averted many incidents: The gear selector is located high in the middle of the panel so it's hard to miss. The flap switch is located low on the center console, along with the trim/flap indicators

That's an M20K's TSIO-360 fitted with the Turboplus aftermarket intercooler system, top. Two-blade propellers (bottom) are common on the 231/252, but there's an STC for an MT four-blade composite prop.

and, in the 252, cowl flap controls. The power gauges are on the far right and angled toward the pilot. Engine gauges are well-placed, right under the glareshield in front of the pilot. The panel also has a good selection of annunciator lights at the top of the radio stack.

MAINTAINING IT

From an airframe standpoint, Mooneys are relatively trouble-free. Long-standing caveats include the potential for corrosion of the cabin frame tubes—particularly if the windows develop leaks—and the typical fuel tank leaks that plague all Mooneys. Keep it hangared—and covered when outside—to keep the trouble to a minimum. But the systems in general are simple and robust. The steel gear legs gear have no oleo struts, relying instead on rubber donuts for shock absorption. These need to be replaced periodically. There's no complex electro-hydraulic system driving the gear as is found on Cessnas—Mooneys are electromechanical. The flaps, too, are electric; both are relatively trouble-free.

The powerplant, however, is another matter. Difficulties fall into several categories: magnetos, con rods, cylinders and turbos. Most airplanes have been retrofitted with pressurized mags but check any used model to be sure. The same applies to connecting rods. The suspect rods are Continental part number 626119 and have a C logo with a circle around it. Only a barn dweller would still have the old ones.

Many turbocharged models encounter mid-run cylinder problems of some sort and the K-model is no different. These include the full litany: worn valves and guides, broken rings and cracked jugs. Mid-time turbo and magneto replacements aren't uncommon, but they aren't a sure bet, either. The 231's fixed wastegate means the turbo is working constantly and the engine is susceptible to overboosting.

The 252 doesn't suffer these problems, although it had trouble with cracked tubes in the induction system before Continental came up with flexible tubing. Even though the 252's engine installation is less troublesome than the 231's, temperatures and stresses on turbocharged engines are greater than on normally aspirated engines. Regular inspections and proactive maintenance are a must for reliable dispatch rates.

AVIONICS, CLUBS AND MODS

The 231/252 is worthy of modern avionics and a market scan shows some owners go to town with major upgrades—we're talking packages that near $100,000 including all-in-one digital engine monitors and new panel fabrication. Others make do with original King Silver Crown radios.

At press time Garmin announced an STC for the new GFC500 autopilot in the M20K, and there's also the G3X Touch integrated avionics. If you're considering a 231/252 and don't plan to upgrade the autopilot,

Notice the placement of the landing gear switch up high on the M20K's panel in the photo above. That's a Garmin G500 PFD to the left of the switch.

pay close attention to the performance of the existing system, which is likely the King KFC150. Earlier servos are extinct and flat-rate repair for the system components is hefty. S-TEC has a multitude of STC approvals for the M20K and you might find one with an S-TEC 55 series. Again, pay attention to the performance during the prebuy.

There are fewer speed mods for the K-model than for earlier Mooney types, such as the C, F and J models. Single-piece belly skins, minor speed mods, rudder and elevator hinge covers and oversized bushing kits for the nosegear are available from Lake Aero Style and Repair (www.lasar.com, 800-954-5619). The company, an FAA repair station, also advertises that it does ADS-B retrofits for Mooney models.

LoPresti Aviation (www.lopresti aviation.com) has an HID landing light for the K-model and hubcaps with filler valve access holes, while Precise Flight (www.preciseflight.com) has speedbrakes and the Pulselite system.

A big-dollar mod, the Rocket conversion, replaces the TSIO-360 with a 305-HP Continental TSIO-520-NB, yielding 220-knot-plus cruise speeds. Although the conversion is discontinued, these turn up on the used market.

Perhaps the most desirable mod for a 231 that makes it more like a 252 is an intercooler. One system—the Turboplus—has been highly recommended by M20K owners and it comes from Turboplus Aircraft Systems (www.tuboplus.com) in Gig Harbor, Washington. Turboplus says it was the first company to bring intercooling for GA singles and twins in the early 1980s and there are thousands of Turboplus intercoolers and induction systems in use today.

The company says its M20K intercooler kit can yield a max speed of 241 MPH at 24,000 feet, and 170 knots true airspeed at 10,000 feet and 65 percent power, with the added benefit of lower cylinder head temperatures. The STC'd kit for the Mooney M20K is $5995 and the estimated installation labor is around 18 hours.

"My conclusion is that the Turboplus intercooler provides much improved intake manifold cooling and an increase of 3 inches in available manifold pressure at altitudes above the 13,500-foot critical altitude, while providing significant performance benefits across the board to the hot-running, non-intercooled engine in the 231 M20K," reader Geoff Lee said of the system.

He's documented the installation

Mooney 231/252

(continued from page 31)

in a well-written tech guide that's available at tinyurl.com/y4a6ahga. That's a link to *The Mooney Flyer* (www.themooneyflyer.com), the official magazine of the Mooney community.

Speaking of the Mooney community, there are a some good Mooney associations and forums, including the Mooney Aircraft Pilots Association. It has good membership benefits, technical support and magazines. Contact MAPA at www.mooneypilots.com. There is also www.mooneyspace.com, which has a linked club directory, plus active forums and blogs. There's also www.themooneyflyer.com. If there are others that offer accurate tech data and resources, we want to know about them.

The current Aircraft Bluebook says the average overhaul cost of a Continental TSIO-360-MB1 is around $40,000.

OWNER COMMENTS

I recently bought my M20K 252 after previously owning four M20Cs, two M20Js and an M20R. So, I thought I would try a turbo Mooney. This K-model just came out of annual inspection by Don Maxwell in Longview, Texas, who is a well-respected Mooney service tech. It was being brokered by Jimmy Garrison—also a highly respected Mooney dealer in Spring Branch, Texas, and I believe there was no prebuy necessary, which is rare in the used aircraft world.

My very first impression of the M20K Mooney was its terrible useful load allows only two lightweight people and a couple of overnight bags if you fill it with fuel. My second impression is what a ground-hogging "dog" it is when taking off at gross weight. Those two things alone are quite different from any of my previous Mooney models.

Mine has been beautifully retrofitted with a full Garmin avionics suite including G500 PFD, GTN750 and GTN650 touchscreen navigators, a GTX 330 transponder and GDL88 ADS-B. The suite is interfaced with a King KFC150 autopilot and the cabin has power plug-in connections for the fine Bose A20 headsets—what a spectacular IFR panel.

Topping it all off is new paint and leather interior. This is essentially a new Mooney at a fraction of the cost of a 2019 model.

Even with the aforementioned weak points, I am happy with this Mooney. I am considering the Encore gross weight increase mod, but the cost is around $14,000. Of course, then you need a longer runway to get that heavy slug airborne. I'm still mulling that over.

Bill Pearson
San Antonio, Texas

BEECH DUKE

It's time to take a look at the used Beech Duke market for the *Aviation Consumer* Used Aircraft Guide. We want to know what it's like to own these sleek twins, how much they cost to operate, maintain and insure and what they're like to fly. If you'd like your Duke 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 Duke by Sept. 10, 2019, to:

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