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Crashworthiness: Remembering the Lessons

I continue to be impressed with the ability of LSA designers to meet the strange and arbitrary weight limit for the category and still carry a reasonable amount of fuel. At the same time, I am hearing more and more questions about the crashworthiness of the airplanes and whether the manufacturer of such a flyweight machine can incorporate some degree of protection against a quick, unplanned stop for those who fly in them.

The argument "we build them to fly, not to crash" was rendered moot 50 years ago because of the simple reality that designers know very well that their airplanes will crash and they have an obligation to avoid putting something in the airplane that makes the effect of the crash worse.

My observation is that modern designers may not have been exposed to or have forgotten the hard-learned basics of crashworthiness from the full-scale crash tests performed by NASA and others in the 1950s-1970s.

Some lessons have stuck, such as the absolute requirement for lap and upper torso restraint. I'm not sure all designers understand that even with a restraint system, there has to be "flail space" for each occupant because there is some slack in the belts and the fabric stretches when loaded. That means that there should not be hard or sharp objects in that space.

The full-scale crash tests at NASA-Langley showed that airplanes do not behave quite the same as do cars during a crash sequence. Airplanes commonly come to grief on dirt or grass, so the gear drag pulls the nose downward. The effect on the pilot is that s/he goes forward and up, and may hit the ceiling before the restraint lap belt and shoulder harness pulls back and down.

Cessna saw this back in the 1960s and made sure its airplanes and jets had no switches or radio knobs on the ceiling as those were head injuries waiting to happen. Despite the lessons of the NASA tests, I still see hard protrusions just in front of and above pilots' heads even in modern, Part 23 airplanes.

Putting a fuel tank in front of the pilot is so obviously dangerous that, with today's knowledge, I don't know how a manufacturer could defend the design in a post-crash fire lawsuit. The Ercoupe, J-3 Cub, Champ and similar designs are known for parboiling people in relatively low-impact crashes when the engine comes back and opens up the fuel tank— I can think of no logical reason for such a design in this century.

I'm not crazy about fuel tanks anywhere in the fuselage, but I've seen no crash data to show that fuel tanks aft of the occupants are dangerous.

Beech, Piper and Cessna have long shown that the correct routing of fuel lines is along and behind (if possible) major structural members so that they receive some protection during an impact sequence.

I like the low stall speeds of LSAs. Touching down slowly, with minimal energy to dissipate (force of impact is a squared function), makes a difference in crash survivability. Nevertheless, a sudden stop from 20 or 30 knots can be just as fatal as one from 60 knots if the impact energy is not absorbed by the structure and the occupants don't have adequate flail space for the restraint system installed, or the airplane catches fire before they can get out.

I think Paul Bertorelli's perceptive article on LSA safety on page 4 is going to generate a much-needed discussion in the industry. It is an excellent starting place for opening a candid conversation on LSA crashworthiness because we all know that, sadly, not every flight goes according to plan. —*Rick Durden*

ADS-B Portables

I am not clear about the options for interfacing ADS-B portable receivers (September *Aviation Consumer*) with various software and platforms. Do the receivers output a standardized string, be it by cable, Wi-Fi or Bluetooth, that can be received and utilized by any software and platform as long as the software contains ADS-B receiver support? Or is data output unique to each manufacturer?

For example, as far as external GPS receivers are concerned (most of them use Bluetooth), as long as the software supports external GPS (via Bluetooth in this case), one should generally be able to use any GPS receiver, regardless of software publisher or platform.

Rumen
Via e-mail

Portable ADS-B receivers are paired with compatible applications. It doesn't matter whether it's an Android or Apple platform, so long as the application is compatible with the functionality of the ADS-B unit. For example, Garmin's GDL39 portable ADS-B works with a variety of Garmin portable GPS units, with some limitations in traffic, while full functionality is achieved with Garmin's Pilot application.

SkyRadar has the SkyRadar application, while Sporty's Stratus is designed around the ForeFlight app.

We believe it is best to decide which application works best for you before buying a receiver.

GAMIjectors

I just read the article on GAMIjectors in the October issue and saw something that doesn't match my understanding of what GAMIjectors do. It is said that they allow each cylinder to receive the same amount of fuel. I thought they were designed to correctly match the amount of fuel necessary to match the amount of air delivered to each cylinder by the induction system.

It's my understanding that most induction systems don't provide equal air flow to each cylinder and therefore the fuel/air ratio varies from cylinder to cylinder. By matching fuel flow to air flow, GAMIjectors maintain a correct fuel-to-air ratio among the cylinders.

It's my understanding that by doing this matching, the power produced by each cylinder differs slightly among the cylinders on an engine, but the fuel-to-air ratio is made equal. This is confirmed by EGTs peaking at the same fuel flow and is accomplished by adjusting the fuel flow to each cylinder as necessary with highly calibrated fuel injectors.

Am I wrong or have I just missed something in my research on the value of LOP using GAMIjectors on my Continental IO-520 in my V35B Bonanza?

Ted Sigtenhorst
Via e-mail

The statement that GAMIjectors allow each cylinder to receive the same amount of fuel is correct. The airflow to each cylinder is determined by the volumetric efficiency of each cylinder and is, in no way, related to the fuel injection system. As a rule, the airflows match fairly well. That has nothing to do with why GAMIjectors were invented.

The problem faced was the log-runner induction plumbing of the Continental large-displacement engines. The fuel injection system is "constant flow," and some of the fuel that is being delivered to the rear cylinder induction ports moves back into the induction system and then forward to the next cylinders in the line. That's why the rear cylinders tend to run leaner and the forward richer. GAMIjectors address this by sending less fuel to the middle and forward cylinders, in the correct amounts, to result in balanced fuel/air ratios.

XM, Radar Disagreement

In the August issue article, Radar Upgrades, you described a disturbing incident involving a significant disagreement between the XM NEXRAD data and the on-board aircraft radar. Do you know why there was a disagreement? Was the XM image older than five minutes? I replaced my GPSMAP 496 with a factory-overhauled 496 (Garmin suspected that the internal clock in my original 496 was a bit "off " and was rejecting new images). The factory-overhauled 496 works better, but it occasionally (and always at the worst time) stops updating for 10 or more minutes.

David Ansley
Nokomis, Florida

The XM data was coming in through a HeadsUp XMD76A receiver, playing on an Avidyne EX500 MFD. The time stamp on the NEXRAD data flow was around six minutes, and I'm not sure it updated for a good 10 minutes or so. Long before that, we were spinning the knobs on the ship's radar and looking at the buildups with our eyeballs.

Paul's Departure

What a disappointment it is to learn that Paul Bertorelli is departing the editor position. His depth of knowledge and breadth of experience is probably irreplaceable.

Charles Keen
Boynton Beach, Florida

Paul, thank you for the great job you have done. Good luck with your future projects. I was pleased to learn you'll still be involved with *Aviation Consumer.*

Paul Hollowell
Venice, Florida

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The Tecnam line has only one fatality, but it wasn't this Bravo, which wound up in a Texas backyard after an engine failure. Both occupants were uninjured.

AIRCRAFT SAFETY REVIEW

LSA Accident Survey: Low Fatals, High Overall

Seven years worth of data show that landing accidents among LSAs are higher than for GA as a whole, but fatal accidents match the overall average.

by Paul Bertorelli

When the light sport aircraft rule was busy being born a decade ago, it was intended to be a poster child for inspired innovation driven by reduced regulation. While there's no argument that LSA has ignited a bushel of new designs, not much has been said about safety and crashworthiness. Is it reasonable to assume that a 1320-pound airplane will be as safe as one weighing 300 or 500 pounds more?

In our view, the proof is in the flying and in the accident record. The U.S. LSA fleet now has some seven years of operational history, which we think is sufficient to warrant a first look. For this report, we examined the accident histories of the top 10 selling LSA manufacturers in the U.S. Our initial findings reveal that for this fleet, the fatal accident rate is comparable to GA in general, but the overall accident rate is substantially higher because LSAs suffer many more landing accidents than do larger and heavier aircraft.

Can a 1320-pound airplane be as safe as one weighing 300 or 500 pounds more?

And some models are much worse than others. We also confirmed another trend we've heard anecdotally: Some LSAs break a lot. Amidst the accident reports are incidents of broken gear legs, missing wheels and surprise collapses of landing gear components. In some cases, these were the cause of accidents, but the result in others.

SMALL NUMBER SYNDROME

One caveat up front: Even though we looked at 10 manufacturers of LSAs for a seven-year reporting period, by our calculation, this sums to about 1440 aircraft and a calculated total fleet hours of about 960,000. By aviation statistical standards, these are small numbers, thus any calculated rates are susceptible to wide swings based on just a few occurrences. In our view, then, it's too soon to draw blanket conclusions about LSA fleet safety in general. We simply need more flight hours. But it is, nonetheless, fair to report on some early trends that emerge from the accident data.

As we did for our Cirrus accident report in the January 2012 issue of *Aviation Consumer*, we calculated accident rates based on U.S. accidents reported to the NTSB between 2005 and 2012. We calculated fleet hours by stratifying manufacturer registrations by year and assigning each aircraft estimated flight hours for that year. We used estimated flight hours—and our own surveys as

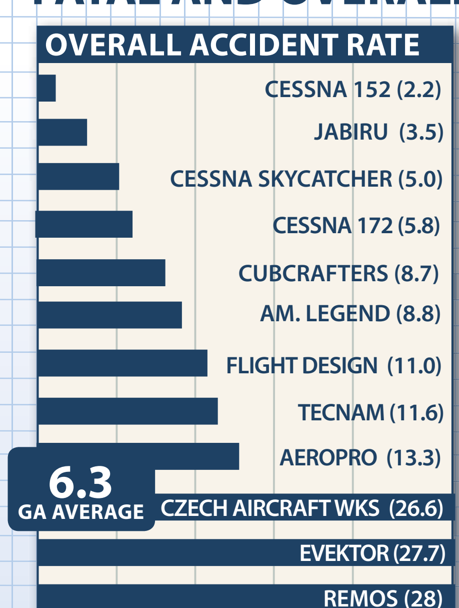
CHECKLIST

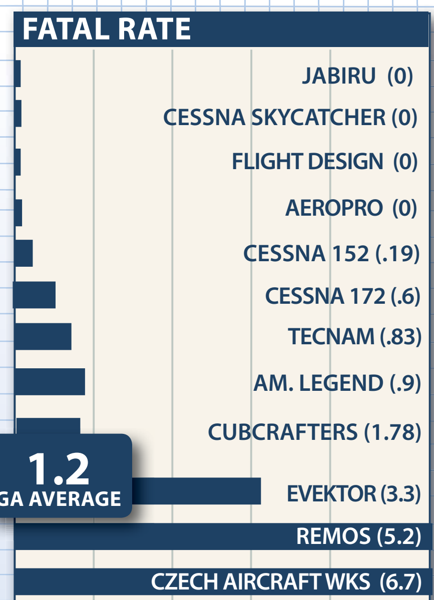
Although the fleet is still young, fatal accidents aren't out of the GA norm.

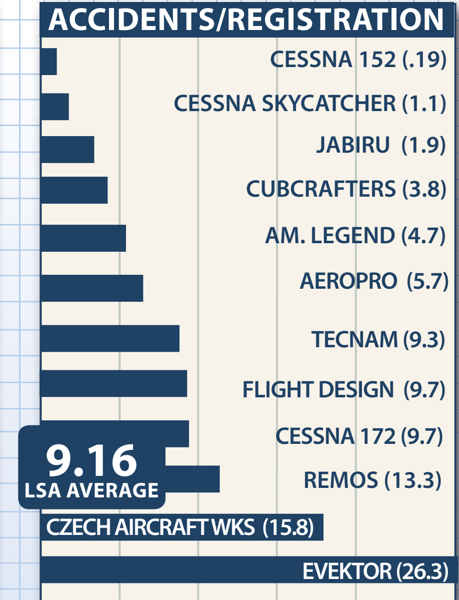
Landing accidents are more frequent than with other light aircraft.

The data shows that three models, Remos, Evektor and Czech Sport Cruiser, have measurably higher accident rates.

FATAL AND OVERALL RATES COMPARED







ANALYSIS METHODOLOGY

Accident data given here is accidents per 100,000 hours of flight. Accidents per registration is accidents per 100 airplanes registered. Data and accidents apply to U.S. fleet only. Fleet hours were calculated for each model by multiplying average annual hours flown given by *Aircraft Bluebook Price Digest* by the number of that model given on the FAA registry. The aircraft populations were stratified by year and each model was given credit for a full year of flying, regardless of what month it went into service. Accident reporting period for most models was 2005 to 2012 and for each LSA manufacturer, all models were combined into a single fleet. The Cessna 172 data includes only S models built since 1997. The Cessna 152 data includes only accidents and flight time during the reported period.

backup—from the *Aircraft Bluebook Price Digest*. These were typically 100 to 150 hours per year, per aircraft. While it's true that many aircraft in the LSA fleet used for trainers fly 300 or more hours per year, it's also true that this offsets those privately owned aircraft that fly 50 hours a year. None of the manufacturers except Cessna provided us with their own fleet-hour estimates, nor could any offer accurate information on how many aircraft are privately owned versus flightschool operated.

Although we've tried to compile all the accidents, we know we've missed some. Some simply aren't reported to the NTSB, while others are reported but are miscoded by the NTSB with the wrong aircraft name or model or a non-standard manufacturer name. Suffice to say we scoured the data and included all the accidents we could find.

LOW FATALS

This group of LSAs had an admirably low rate of fatal accidents. Taken as a composite, our data for this group showed a fatal rate of 1.4/100,000 flight hours. That's a bit higher than the GA average of 1.2, but given our small sample size, the difference is statistically insignificant.

Four manufacturers—Cessna, Jabiru, Flight Design and Aeropro—had no fatal accidents at all in the U.S. For Flight Design, which has the largest LSA fleet and the most hours, we think that's a remarkable record.

It's less rosy for Flight Design when the overall accident rate is considered, but more on that later.

Also less impressive is the fact that 10 of the 14 fatal accidents involved three manufacturers—Remos, Evektor and Czech Aircraft Works, which makes the Sport Cruiser LSA. These are definite outliers in our survey group, but it's not clear why.

The overwhelming majority of LSA accidents are runway loss of control events, which are rarely fatal. There's no discernible pattern to the fatal accidents that we could see. Evektor had a couple of VFR-into-IMC crashes and a stall spin. The Sport Cruiser had four fatals, three of which looked like simple loss of con-

TOP VS. BOTTOM

For U.S. accidents, the Evektor line, left, finishes at the bottom of our LSA accident survey, with 26 accidents per 100 registrations. The Jabiru, right, and Cessna Skycatcher have the top overall and accidents/registration record.

LSA WRECKS: THE GEEZER FACTOR

It's well-established that the light sport industry is buoyed along by so-called full-circle pilots—older pilots who've dropped or don't want to fuss with a medical. These owners are also wealthy enough to buy new LSAs. Unfortunately, they may also be driving the high accident rate. We spoke to a dozen CFIs specializing in light sport instruction, and nearly every one of them told us that older pilots stepping down from heavier certified airplanes struggle with the light control forces in LSAs.

"It's real simple. They have an incorrect attitude…if I can fly a 182, I can fly this little thing," says Jerry Eichenberger, who operates a flight-school in central Ohio with a Tecnam and an old Champ. "But if they've ever flown an airplane as lightly wing loaded as a typical LSA, it was 30 years ago. These airplanes take a significant amount of transition training. They don't fly like a 182," he adds.

He maintains that there aren't really any control issues for landing LSAs as a class. It's a version of taildragger versus tricycle gear. If you learned in the former, you'll have no trouble with it.

Not everyone agrees that's true of all LSAs, however. Jerry Plante told us the flight school where he instructs had a couple of Sport Cruisers, which the instructors called "Sport Bruisers." Plante said no one wanted to fly them twice. "I've had my head slammed against the canopy several times. It's not a fun airplane to fly," he said. One pilot pushed over in pitch hard enough to float a fire extinguisher off the luggage area and drive it through the canopy; it departed the airplane. The school eventually got rid of the LSAs.

What exactly is the problem here?

"What I typically see is that students are flaring high and it's a low inertia airplane; it pancakes in. Call it a carrier landing," says Larry Cazier, who's instructing in a RANS S6 tricycle gear. He's developed a method to simply fly the airplane onto the runway with a little power.

We were surprised to hear from a few instructors teaching in taildragger LSAs and also soloing and renting those airplanes. (Yes, it takes expensive insurance.) What's involved there?

"It comes down to experienced pilots not used to using a rudder," says George Hoover, who teaches in a Cub Crafters Sport Cub in Mesa, Arizona. "They're behind the airplane. It's light. You can feel everything," he adds. Younger pilots generally do better in any airplanes, but also in LSAs.

Earl Kessler, who instructs in Carson City, Nevada, told us he had an exceptional young student who soloed a Cessna 172 in only seven hours. When he put the student into a Zenith LSA, they both got a surprise. "He couldn't control it. I had to grab the stick to stop the PIOs. It just takes a finer touch to fly an LSA," Kessler said.

None of the schools or instructors we talked to suggested that LSAs aren't up the pilot-training task. Indeed, one school operating Flight Design airplanes described them as "awesome." But the general consensus is that it'll take experienced pilots longer to transition into an LSA, and a new pilot may need a few more hours than he'd need in a 152 to solo.

George Hoover with Sport Cub: "New people are much easier to start with. They don't have anything to get in their way."

trol. The reports don't offer enough detail to speculate beyond that. We have noted that the Sport Cruiser's control forces are much lighter than other LSAs we've flown, and instructors we've interviewed say this is a problem. Also, three of the accidents involved issues in closing and securing the airplane's bubble canopy. That came up in other models' accidents, too.

Remos—with four fatals—was unique for having at least two them caused by apparent airframe mechanical failures. The aircraft is among a number of LSAs with readily foldable wings. In one accident, the ailerons were found disconnected, in a second, quick fasteners for the elevator weren't secure. Two of the other fatal accidents can just be considered flukes. A Legend Cub occupant drowned after the airplane ditched in Lake Michigan, and a CubCrafter's LSA disappeared and was assumed to be a fatal accident. CubCrafters also had a stall-related fatal.

EVERYTHING ELSE

Beyond the fatals, the pattern of LSA accidents is somewhat different from the most obvious airplane to compare them to: the Cessna 152. To illuminate the notion of how many 152s are flying, its fleet hours are about seven times that of all the LSAs combined during the survey period. Yet its fatal rate is an admirable 0.19/100,000 hours and its overall rate is 2.2, a third of the GA average.

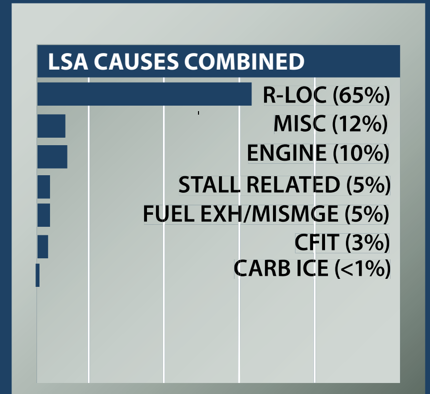
The 152's accident pattern is slightly different than the LSAs as a whole. Things like fuel exhaustion and mismanagement, stalls, carb icing and engine stoppages show up as factors in both the 152 and in LSAs.

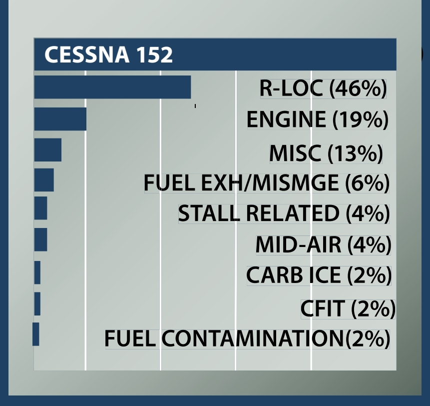
But the larger difference is what happens during landings and takeoffs. Some 65 percent of LSA accidents are what we call R-LOCs—runway loss of control. For the 152, 49 percent are R-LOCs, and the average among the last dozen used aircraft we've researched is about 28 percent.

Conceding the small numbers in our survey, this seems to confirm what we've said in LSA reviews almost from day one: They are simply more difficult to land than heavier airplanes, more susceptible to PIOs and more likely to be easily disturbed by crosswinds and gusts. Some are so exceptionally light in control forces

CRASH CAUSES SORTED

The graphics at right show how LSA crashes as a composite breakdown by cause. By far, runway loss of control (R-LOC) leads the list, followed by miscellaneous causes and engine failures. Stall-related accidents, many of which occur on landing or takeoff, are similar in occurence rate to the Cessna 152. Although the Rotax engines used in most LSAs are generally reliable, the 10 percent failure rate is significant, in our view. In many cases, the causes is listed as unknown.





that instructors tell us they have to constantly guard the controls during landings. (See the sidebar at left for more.) Given that we know we don't have all of the LSA accidents listed, we suspect the R-LOC rate is somewhat higher than we're reporting.

On the other hand, some of the accidents we coded as R-LOCs might more fairly be considered mechanical failures. In a number of accident reports we read, landing gear legs collapsed or wheels departed the airframe during landing. It's not always clear if these happened as a result of a hard landing or just a structural failure. While we wouldn't call them common, they're hardly rare, either. The 152 suffers such damage during some R-LOCs, but it's almost universally limited to the nosegear, which either collapses or bends, damaging the firewall.

We've provided a graphic to illustrate the accident rate for various models expressed on a per-registration basis. This tends to confirm that our flight hours estimates are reasonable, but it also shows that some LSAs seem more accident prone than others. Here, for instance, the Flight Design airplanes do less well.

Despite their favorable fatal accident record, Flight Design airplanes have been involved in 35 accidents, which is about 10 percent of the U.S. fleet or about 9.6 accidents per 100 registrations. Remos, Czech Aircraft Works and Evektor are considerably higher than that, however.

A quarter of the Evektor's U.S. fleet has been involved in accidents, for a whopping 27/100,000 overall rate and the highest accident rate per registration of any of the aircraft examined for this report. We asked Evektor for a comment on this, but the company said it has no explanation. For its part, Flight Design is aware of the high incidence of R-LOCs and it developed a special pilot transition program, which the NTSB made note of in one of its reports.

Design and construction methods were causal factors in some of the LSA accidents we reviewed. For instance, in two cases, pilots of Evektors stepped on the rudder pedal in the opposite control position, commanding left rudder when they wanted right. (Evektor has since added a small bulkhead between the pedal pairs to prevent this.)

We've always been critical of bubble canopies and gullwing doors in airplanes as a post-crash egress risk. However, we haven't seen an established pattern of these design features representing a demonstrated accident hazard in certified airplanes. But that's not true among the LSAs we studied. In one Evektor accident, the canopy opened in flight, causing the pilot to lose control and crash fatally. In the Czech Sport Cruiser, canopy issues were listed in three loss-of-control accidents, two of them involving serious injuries.

One interesting trend is where the Cub clones fit into the accident puzzle. The American Legend and Cub Crafters airplanes—which account for about 440 airplanes between them—are in the middle of the pack for overall rate. Both have low fatal rates, bettered only by the airplanes which have no fatal accidents. Surprisingly, at least to us, a number of these airplanes are in flightschool use.

CONCLUSIONS

We're considering this report as a marker for another review of the topic of LSA safety five years hence, at which time we would expect to see as many as three million flight hours. We'll know more about trends then. In the meantime, we don't think it's fair to draw any take-it-to-the-bank conclusions from the minimal accident data available to us for now.

Nonetheless, some observations are fair. Clearly, instructors, flight-schools and the industry in general should consider how the rate of landing accidents might be tamped down. If it's as high five years from now as it is today, the insurers will be looking at a lot of wrecks. And perhaps hiking premiums. Perhaps additional training programs and even some aircraft redesign to address light control forces could help.

Second, in this group of 10 manufacturers, there are three outliers: Evektor, Remos and Czech Sport Aircraft. And they're not just a little outside the mean, but not even visible from inside the wire. In our view, with similar fleet sizes, the huge disparity between Jabiru or the Skycatcher and the three bottom airplanes in our survey is probably meaningful. The higher fatal and overall accident rates could have to do with the airplanes themselves or their operational environments. Our view is that this fleet bears watching.

For the time being, we think the LSA accident record is neither laudable nor alarming, but middle of the road. The takeaway from our research is this: If you fly an LSA, the best way to avoid your own NTSB entry is to keep your landing skills razor sharp and leave it in the hangar when the wind is gusting above 20 knots.

Budget Transponders: Sandia, Trig Save Space

We think digital transponder upgrades make better sense than repairing old ones. Models from Sandia and Trig make the investment worth it.

CHECKLIST

New transponders bring useful features and advanced interface potential.

The coming ADS-B mandate muddies the decision-making process.

Antenna and encoder swaps drive the installation costs up.

by Larry Anglisano

Aside from digital displays and push-button features, entry-level transponders have been slow to advance. That's changing—since manufacturers are developing new models that save panel space, simplify installation and include advanced features as standard.

Still, transponders are one of the gotta-have systems in which owners hate to invest. For some, the year 2020 ADS-B mandate is a convenient reason to sit on the fence and wait out a transponder upgrade. While this could be smart thinking, you'll still need traditional 1090 MHz transponder equipment in a full-up ADS-B interface. Here's a look at entry-level models that get the job done without busting the budget. We looked at digital transponders in the $3000 price point—our idea of a budget upgrade. You'll be pleasantly surprised that most models are forward-engineered and designed as multi-function devices. Better yet, they might offer growth potential in an evolving ADS-B world, where you'll still need a traditional transponder.

SYSTEM ESSENTIALS

One step in a transponder upgrade is to evaluate the condition and age of the existing antenna and altitude encoding system. These supporting systems are key to transponder performance and can often short-change the interface as a whole.

That's because the transponder relies on the L-Band antenna and coaxial cabling to keep signal loss and other parameters to within a tight tolerance.

The entire transponder system is evaluated during biennial certification, which is governed by FAR 91.413. During this test, technicians are looking for specific performance characteristics to determine the overall health of the system. Ask the shop if your system barely passed or fell well within specs. Many issues related to poor performance are caused by old antennas and cabling. We advocate replacing these systems during transponder upgrades—they're that critical in performance and long-term reliability.

When it comes time to replace antennas and encoders, for example, don't skimp on quality. For example, a fiberglass L-Band blade antenna will cost a bit more than a flimsy metal rod and ball antenna, but will yield better performance and offer more durability for the long term.

The Sandia STX165, left, is a new transponder that has an integral altitude encoder. Its space-saving design makes it a good player in LSAs and tight panels. Garmin's GTX327, below, has proven reliability, rich features and a good display that has an automatic night mode.

The same goes for altitude encoders. Our rule of thumb is to replace the encoder and the transponder at the same time. Encoder technology has improved over the years, with most current-production models requiring minimal warm-up time and infrequent calibration. Encoder swaps could add several hundred dollars to a transponder installation, but that's changing, as manufacturers wisely integrate altitude encoding systems inside the transponder.

But even basic, entry-level transponder installations have become more complex, due to a higher level of interfacing. Be sure to budget for the extra work and down time required for connecting the transponder to a compatible GPS, the installation of optional yoke-mounted ident switches and additional switching control that's required in a dual-transponder setup.

SANDIA STX165

We're impressed with the Sandia line of altitude encoders, cooling fans and now, the STX165 budget transponder. Designed for tight spaces, the STX 165 is a self-contained, panel-mounted Mode-C unit that's designed to be rear-mounted in a 3-ATI instrument cut-out. There's also the STX165R for remote mounting. Both units have a built-in, 35,000-foot altitude encoder, which saves the installation effort of remote-mounting an encoder. The integral encoder supplies altitude data to the STX 165 for altitude reporting while also outputting pressure altitude data on an RS 232 serial data bus, for interfacing with other avionics systems that require altitude data input. Serial altitude data is a common requirement when interfacing with GPS navigators, altitude alerters, and other integrated systems, and the integrated encoder inside the STX165 makes the process seamless.

Speaking of integration, we like that the Sandia STP 78 temperature probe can be interfaced with the STX165 as an optional input, for displaying OAT, density altitude and icing alerts. The icing alert will come on at a preset temperature that is selected by the user, when configured in the user set-up mode. The STX165 has a dirt-cheap price of $1700. Sandia told us they're working on an upgrade solution for ADS-B play.

Tough call—a KT76C, right, is determined to have a failed cavity. Ultimately, the radio stack is opened up to install a new Garmin GTX327, which ditches the cavity and adds nice automation to an existing GNS430, below right.

TRIG AVIONICS

Scotland-based Trig Avionics, which sells its products through an established U.S. dealer network, including mail-order house Aircraft Spruce and Specialty, offers low-cost, Mode-S transponders. These are aimed toward LSA, experimentals and aircraft with limited electrical systems. Some models are certified to TSO C166B standards for meeting the ADS-B out specifications.

The Trig transponder family includes the TT31—a unit that can slide into a King KT76A mounting rack, utilizing some of the existing wiring. The TT31, which doesn't use a cavity tube, outputs 240 watts, while drawing low current. It has a straight-forward and intuitive feature set that includes timer functions, altitude monitoring and a bright LCD display.

Trig says the TT21 and the TT22 models are the the smallest Mode-S transponders on the market. To afford a small footprint, the units are designed as two-piece systems, to include a control head and a remote transceiver that includes an integrated altitude encoder. The control head houses an LCD screen, with coventional rotary knobs and push-buttons. While designed for small aircraft, we think the hardware is rugged. The control heads are splash-proof, making them tough enough for water ops and open cockpit applications. Like the bigger

MODEL	THEORY	PRICE	MOUNT	DISPLAY
GARMIN				
GTX327	MODE A/C	$2545	RADIO RACK	DSTN LCD
GTX32	**MODE A/C**	$2645	REMOTE	N/A
TRIG				
TT21	MODE S	$2265	2-INCH ROUND	BACKLIT LCD
TT22	MODE S	$3071	2-INCH ROUND	BACKLIT LCD
TT31	MODE S	$2605	RADIO RACK	BACKLIT LED
SANDIA				
STX165	MODE A/C	$1700	3-ATI ROUND	BACKLIT LED
BECKER				
ATC4401 50K'	MODE A/C	$2570	2-INCH ROUND	BACKLIT LCD
ATC6401 50K'	MODE S	$2985	2-INCH ROUND	BACKLIT LCD
BENDIX/KING				
KT76C	MODE A/C	$3286	RADIO RACK	GAS DISCHARGE

ADS-B: TRANSPONDER'S GOTTA STAY

A common confusion surrounding the January 1, 2020, ADS-B mandate stems from whether or not you'll still need a traditional 1090 MHz-transponder. The short answer is yes, because the ADS–B equipage mandate does not eliminate the requirement for transponders, TCAS traffic systems, or primary radars. Transponder-based ADS-B systems will still be required to meet the requirements of FAR 91.413.

What about Mode S requirements? Nothing has changed here, either. The FAA says that any aircraft that's required to— or that voluntarily has—TCAS, must also be equipped with a Mode S transponder. TCAS technicalities aside, the transponder squawk codes that exist in today's 1090 MHz transponder environment will still play a role in a full-up ADS-B environment, while also leaving a backup solution in place.

A summary of the existing 2020 ADS-B mandate puts this into perspective. If you operate in airspace that currently requires a Mode C or Mode S transponder, you'll need to be equipped with ADS-B output. The rule says that ADS-B is required for operating in Class A, B or C airspaces, Class E airspace at and above 10,000 feet MSL over the 48 contiguous United States and the District of Columbia, and Class E airspace over the Gulf of Mexico, from the coastline of the U.S. out to 12 nautical miles and above 3000 feet MSL. Even if your operations don't fall into one of these categories, you'll still be required to have ADS-B output when flying from the surface up to 10,000 feet MSL, within 30 miles of most primary Class B airports.

There are two ADS-B solutions which are currently in place, guided by FAA Advisory Circular AC 20-165. These include a 1090 MHz ES extended squitter transponder or a UAT universal access transceiver, which operates on the 978 MHz frequency. For aircraft that only fly below 18,000 feet and only in the U.S. , a UAT solution will suffice. This also means that using the 978 MHz UAT frequency to comply with ADS-B will allow you to keep the Mode C or Mode S transponder that you may already have, or any of the entry-level units that you might buy now. If you have to have 1090ES, you'll need a mandate-approved, Mode S model, equipped with extended squitter. Given the limited bandwidth of the 1090 MHz frequency, this is an ADS-B out solution only. You won't receive weather or traffic—you'll need a UAT for those capabilities.

Garmin, with their GDL88 UAT transceiver that's due out by the end of this year, attempts to offer lower-flying aircraft a one-box solution, while retaining a traditional transponder. FreeFlight Systems will offer a similar one-box solution with its Rangr series.

According to Garmin, the GDL88—which starts at $3995—has a low-power transceiver that's smart enough to ping most Mode C transponders and then download the squawk code to the ADS-B station, so the pilot doesn't have to. The GDL88 will be available with an integral WAAS GPS receiver, fullfilling the ADS-B mandate as an approved postional source. For WAAS-equipped aircraft, it's available without a GPS.

At this point, we don't think ADS-B should govern a transponder purchase. On the other hand, you'll want to start thinking about how you'll deal with the mandate. Which ADS-B equipment you buy will depend on your mission and your aircraft. For legacy LSA models and lesser aircraft, compact transponders like the Trig and Sandia offerings could be the easiest, no-frills solution. For advanced missions, recently announced one-box UAT solutions—like the Garmin GDL88—are starting to make more sense, in our view, with a reliable transponder playing an important role in the interface.

TT31, the TT21 and 22-series have bragging rights to power efficiency—drawing low amounts of current.

Speaking of power, the TT21 outputs a measly 130 watts, making it a non-player in higher-flying aircraft. The TT22, however, outputs 250 watts, which will work in most all applications. It's also the first certified compact transponder to comply with TSO C166b, which is the 1090E specification for the FAA's 2020 ADS-B output requirement

GARMIN GTX

The $2545 digital GTX327 is a popular upgrade for a wide range of aircraft. This popularity is earned, since it brings all of the modern amenities you could want in a transponder, including touch-key operation and a display that offers a trick video mode for night operations. It's designed with a short chassis that preserves space behind the panel. Owners who've upgraded to the grander GTX330 Mode S unit often retain the GTS327 as a secondary backup, and it plays nicely in this configuration. Speaking of playing nicely, the remote version of the GTX327 is the GTX32. It can interface with the GTN-series touchscreen navigators for remote transponder control, saving panel space that might be required for the huge GTN750 touchscreen navigator. If you have a Garmin GNS or GTN navigator, the GTX327 complements them and furthers the automation, providing automatic timer operation and transponder-mode selection, activated by the GPS ground speed. For instance, if you start the takeoff roll and forget to switch the unit to ALT mode, a signal from the connected GPS will do it for you, once the groundspeed comes alive. Similarly, the transponder can switch back to standby on landing. The GPS groundspeed also activates a built-in flight timer, in addition to a user-controlled count-up and count-down timer, which is displayed in a data field on the right side of the screen. This data field can also be configured to display pressure altitude.

BENDIX/KING

The entry-level digital transponder in the current Bendix/King line is the KT76C. This Mode-C unit is a

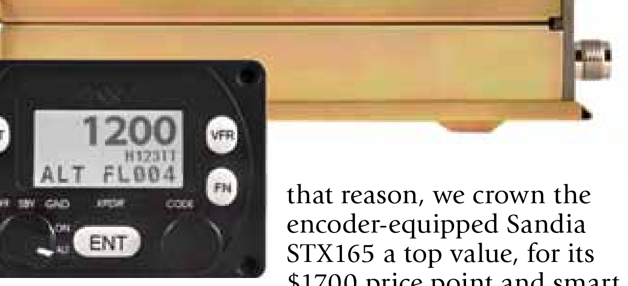
drop-in replacement for the venerable KT76A, making its debut when the company brought the Silver Crown Plus line of avionics to new Cessnas in the late 1990s. While the 200-watt KT76C has a digital front end, it still has a analog cavity tube—a big-bucks component that will inevitably fail. Expect this repair to reach the $1000 mark—questionable for some owners who might be looking for a model that's more modern and that has legs for ADS-B upgrades. As noted, a TRIG TT31 might be a good replacement without having to rewire the interface. We're waiting for the new Bendix/King to offer a fresh model that brings the reliability and performance of the rugged but dated KT76 series. Speaking of the KT76A, Bendix/King still makes it, but we think the KT76C is the better choice.

The KT76C has a bright, gas discharge display that's easy to read in direct sunlight and includes a pressure altitude window for displaying Mode-C data. We like the units light-weight chassis and durable controls. This is a basic unit that doesn't have serial output or integral altitude encoder.

BECKER AVIONICS

Specializing in radios for tight spaces, German manufacturer Becker Avionics offers two transponders that are priced under $3000. The entry-level ATC-4401 is a Mode-C model that's available in two flavors, based on power output and certification criteria. The 175-watt version, with a 15,000 foot service ceiling, is $2365 while the 250-watt model is good for 50,000 and is priced at $2570. Both units fit into a 2.25-inch instrument cutout, weigh under two pounds and have a digital LCD display, automatic VFR button and an integral, on-screen bus voltage monitor. Speaking of its LCD display, we recently flew with an ATC4401 that was installed in a Husky and struggled to see the LCD display. To be fair, the unit was installed low in the instrument panel—a crummy location to mount a small LCD display. Still, the control head has rugged controls that have a positive, high-quality feel.

The entry-level Mode S unit from Becker is the $2985 BXP-6401. It's certified for operation up to 15,000 feet and has the same footprint as the ATC-4401. Becker told us they are gearing up for ADS-B and will have a variety of products to meet the mandate.



The Trig TT31 rack-mounted transponder, above, can easily replace a KT76A. The two-piece TT22, right, is a space-saver and already meets TSO-C166B, for an approved 1090ES ADS-B output.

DECISION TIME

We think anyone faced with a transponder repair that totals more than $500 should consider a whole-unit replacement. It's tough to nail labor costs, but we favor the compact transponders that mount in instrument holes and have integrated encoders. While most entry-level encoders cost a few hundred dollars, installation can cost more than the encoder, depending on the required teardown and wiring changes. For that reason, we crown the encoder-equipped Sandia STX165 a top value, for its $1700 price point and smart design. For existing Garmin GNS navigator owners in need of a transponder, we still think the GTX327 bests in features and interface capability. If you want an approved ADS-B transponder now, Trig can deliver now, with the space-saving TT22. We'll keep tabs on this expanding market that will likely offer more choices at lower prices.

CONTACTS

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Sandia Aerospace
505-341-2930
www.sandia.aero

Trig Avionics
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Spark Plugs: Fine Wire or Massive?

Fine-wire plugs may be worth the higher cost for frequent fliers, but there are trade-offs. Champion has taken some hits recently for cracking insulators.

by Rick Durden

It used to be that we didn't pay a lot of attention to what sort of spark plug was installed in our engines. We put in what our mechanic recommended, complained when they fouled, paid to get them cleaned and gapped at the annual and threw them away when they wore out.

With the electronic engine monitor unlocking many of the combustion mysteries under the hood, increasing attention is being focused on spark plugs, the quality of the spark they produce, how long they last and how their design might save us cash.

If you're running a normally aspirated, large-displacement engine at least 100 hours a year, we think that fine wire plugs will be less expensive than the massive electrode style when you total up the full cost of the plugs, maintenance and possibly fuel efficiency. And, yes, we recognize that the purchase price of fine wire plugs is two to three times higher than massives.

Electronic engine monitors reveal that problems once blamed on other things are due to spark plugs.

It also appears that electronic engine monitors are teaching us that engine problems we used to blame on other things may be more accurately traced to a spark plug malfunction. Thus, we have become concerned about and watching two ongoing issues with reliability of Champion plugs, which we set out in the sidebars to this article.

SOME ANATOMY

There are currently two manufacturers of aircraft spark plugs, Champion and Tempest. Champion has seemingly been involved with powered flight forever, having made plugs for the Curtiss Jenny, a WWI trainer. Tempest, a new comer, took over the Autolite/Unison spark plug line. Both make a full line of massive and fine wire plugs.

Boiled down to the basics, the purpose of an aircraft spark plug is to take some 25,000 volts from a magneto and create a spark that jumps through a spark gap between center and ground electrodes with the proper intensity to ignite a fuel/air mixture effectively, efficiently and without fail.

It's the type of electrodes that is of interest here, because the newer technology version, the fine wire, is more resistant to erosion and fouling in use, needs less maintenance, may produce a little more fuel efficiency and seems to last two to three times as long as massives.

MASSIVES

The massive electrode plug uses, as the name implies, two large ground electrodes on either side of the center electrode. It has a lot of material built in to allow for wear. As with anything to do with engines, the critical factor is metallurgy—the materials used in the electrodes have to stand up to the heat of the spark and combustion.

The nickel-alloy used in massive electrode plugs makes them suitable for about 400 to 500 hours of operation with careful maintenance, and rotating the plugs every 100 hours. We know of massives lasting more than 900 hours on turbocharged engines, particularly if the pilot is careful to aggressively lean during any low-power operation, such as on descent and

A new, fine wire plug (right), showing the single iridium ground electrode. Massive electrode plugs (left), showing the two ground electrodes surrounding center electrode, all are servicable, but are worn.

CHAMPION INSULATOR COMPLAINTS

One of the primary components of a spark plug is the ceramic insulator that surrounds the central electrode. It does precisely as its name states, electrically insulates the central electrode from the external portion of the plug as part of the spark gap and keeps some of the heat from the interior of the plug away from the fuel/air mixture.

Should the insulator crack or have a piece break off, the plug can effectively become a glow plug and cause pre-ignition. That's combustion of the fuel/air mixture early in the combustion stroke and well before the spark plug fires. Bluntly stated, pre-ignition combustion events are the most destructive combustion processes known to affect piston engines.

Once underway, pre-ignition generates high heat in the cylinder and can melt the piston and rings, and potentially destroy the entire engine by pressurizing the crankcase and forcing oil pressure to zero. The symptom is a sudden, major rise in the CHT of the affected cylinder.

Over the past four or five years there have been incidents of pre-ignition in large displacement Continental engines that were traced to cracked or broken insulators on Champion fine wire spark plugs. Initially, the problem seemed to be limited to turbo-normalized and turbo-charged Continental engines.

This lead to Service Bulletins from Tornado Alley Turbo, maker of an STC'd turbonormalizing system as well as from Cirrus Aircraft company, calling for operators to switch from Champion fine wire spark plugs to Champion massives or Tempest plugs.

In the last year, the incidents of cracked and broken insulators expanded to include Champion massive electrode spark plugs and normally aspirated engines, causing many users and fleet operators to switch to Tempest spark plugs.

Our investigation has not revealed any evidence of a pattern of cracking or breaking of insulators in Tempest spark plugs. Why?

The theories for the cause of Champion plug cracking have been evolving over the last 18 months. We understand that Champion's engineering department is working on the matter.

Initially, Champion blamed lean-of-peak engine operation for detonation-induced cracking of the ceramic insulators. That made no sense because if done properly, lean of peak operation gives the engine a wider detonation margin than rich-of-peak operation.

Indeed, Champion has moved on from that position. Our investigation included contact with Aircraft Spark Plug Service, the biggest spark plug reconditioning company in the country. Its president, Jeanne Fenimore, sees hundreds of spark plugs each month.

She stated that she has seen a few cracked or broken insulators. All have been on Champions. She believes the cause is either thermal shock due to a large power reduction when a pilot starts a descent or someone dropping a plug and not admitting it.

Mike Busch, proprietor of Savvy Aircraft Maintenance Management, a company that manages some 400 airplanes, has been actively working on the issue. He reported in a recent EAA webinar that he believes the cracking problem is due to pilots who are doing the "big pull" of the mixture control to move from rich of peak to lean of peak, too slowly. He believes they are lingering in the risk of detonation mixture region—25 to 50 degrees rich of peak EGT—rather than moving the mixture from rich of peak to lean of peak in two to three seconds, as is advocated.

Kevin Gallagher, Manager of Piston and Airframe Products at Champion, said that his company is still researching the matter but agreed that both Fenimore and Busch may be correct. He emphasized how damaging even light detonation events can be and that a pilot who is operating at high power and leans to lean of peak EGT by slowly moving the mixture control is subjecting the engine to detonation events during the transition. He referred to the spark plug insulator as "the canary in the coal mine," being the first component to show the impact of detonation.

We're keeping an open mind on the cause of the insulator cracking events on Champion spark plugs. We note that Tempest plugs are able to withstand an environment that is causing distress to Champions. We are hesitant to fall back on the blame the pilot approach to what may be design or system shortcomings.

In a world where lean of peak is the operating procedure advocated by manufacturers, we think Champion needs to figure out why its insulators are not as robust as Tempest, whether the cause is less than stellar pilot practices or people simply dropping the plugs.

Broken insulator on a Champion plug, right, renders it useless. Champion plugs have a carbon-pile resistor and spring, lower photo.

HOW MUCH RESISTANCE IS FUTILE?

All spark plugs require a resistor to reduce the voltage from the magneto to an appropriate value for the spark that ignites the fuel/air mixture. It's an important component because spark quality matters. If the spark is too intense—resistance is too low—the electrodes will wear quickly.

Weak spark—resistance is too high—can cause excessive lead fouling and hard starting, inconsistent plug firing, high CHTs, poor plug performance at high altitude and in lean-of-peak operations and possibly cross-firing, damaging the magneto.

Nominal resistance for a new plug is 1000 to 2000 ohms. Over the last few years, some owners of Champion plug-equipped airplanes who had ignition problems during runups and in flight on their engine monitors couldn't trace the problem to fouled plugs, wiring harness or magneto problems. But they were finding high plug resistance. When the plugs were replaced, the problems abated.

Cirrus fleet operator Platinum Aviation in Florida began routinely measuring resistance and found values as high as 15,000 to over a million ohms on Champion plugs with relatively low times in service. Those plugs also had high levels of lead fouling and high CHTs in operation.

Most of those plugs passed the bomb test that has been long used to determine whether plugs were producing acceptable spark. The plug is placed in a cleaning/testing device that pressurizes the plug to simulate the stresses of altitude. While the maintenance technician watches through a viewing port, the spark is observed.

Other owners and users report similar results, all on Champion spark plugs. Measurements on Tempest spark plugs showed consistent resistance of between 1000 and 2000 ohms throughout their service life.

Naturally, attention turned to the different design of the plugs. Tempest uses a "fired-in" resistor that is integral to the plug and sealed from atmospheric moisture. Champion uses a carbon pile resistor held in place by a spring and screw. It's subject to corrosion.

Champion says that resistance values may climb in service.

The questions are how much resistance is too much and whether what has been the gold standard evaluation tool, the bomb test, is adequate. Tempest publishes guidelines that give a maximum of 5000 ohms. We observed various sources recommending replacement once resistance reaches 3000 to 5000 ohms.

Others disagree. Jeanne Fenimore, President of Aircraft Spark Plug Service, stands by the bomb test and does not test for resistance. Kevin Gallaher, manager of piston and airframe products at Champion, said that as a manufacturer of complete ignition systems, 60,000 ohms is acceptable. He added that the resistor is dealing with tens of thousands of volts, and measuring it with a nine-volt ohm meter doesn't give a true reading of the resistor's performance.

Gallagher said that Champion's engineering staff is looking at this issue and hopes to publish definitive guidelines for resistor performance in the next six to nine months.

Users tell us they want information and in our view, they don't have enough reliable data to make sound decisions on spark plug purchases. When electronic engine monitors document spark plug performance issues, the affected plug shows high resistance measured with a simple ohm meter and replacement of it with a plug that's in the 1000- to 2000-ohm level clears up the problem.

We don't believe this is just pilots feeling "a little roughness." We'd like to see more hard data on the acceptable range for spark plug resistance. Meanwhile, resistance checks are a quick way to diagnose potential spark plug problems.

on the ground, to avoid lead and carbon fouling. Selecting full rich mixture on descent is a sure way to foul massive plugs.

Figure on a ballpark price of $25 to $40 per plug. The big range is because retail prices vary and they sometimes go on sale. When you're buying 12, it pays to shop around.

Fine wire plugs have a single, small-gauge wire ground. Iridium is the most common material because it's resistant to the inevitable erosion. There's no free lunch, however; iridium is expensive, so fine wire plugs cost two to three times more than massives. Plan on $60 to over $100 a pop.

FINE WIRE ENDURANCE

The resistance to erosion does have a payoff. Fine wire plugs tend to last two to three times longer than massives and 1500 hours in service is not uncommon. Some users claim as much as 2000 hours, although we're a little skeptical of that number. All types of spark plugs are considered to have reached the end of their lives when the electrodes have worn down to half their original width.

They cannot be reused. And no matter what type you use, if you drop one from an inch or higher, it's ruined. Throw it away. No exceptions.

We are convinced that one of the dirty secrets of aviation is that a lot more plugs are dropped than is ever admitted. It's tough to accept that you've just made a $100 bill evaporate because of a simple error.

As might be imagined from looking at the sparking end of the plugs themselves, the fine wire's more open architecture is consistent with it being less prone to lead, carbon or oil fouling than massive electrode plugs. Most maintenance technicians and owners report that massives should be removed, cleaned

continued on page 32

Portable Oxygen: Basic Purchase Advice

Oximeters reveal that more of us need oxygen than not. Here's a look at the wide selection of portable oxygen systems available.

by Rick Durden

For decades, we've more or less complied with the FARs requiring oxygen use above certain altitudes on good faith. But the advent of cheap, easy-to-use medical pulse oximeters has revealed a troubling fact: Even at altitudes below the FAR-required values, many of us are oxygenated poorly enough to benefit from supplemental oxygen. Mild hypoxia—say at 10,000 feet—may very well be debilitating enough to cause judgment errors.

So that argues for both a pulse oximeter and some kind of supplemental oxygen system. Fortunately, since we began covering these products two decades ago, they have become ever more sophisticated and cost effective. There's wide choice in price, size, accessories and even new products that conserve oxygen, meaning that many owners who use it only at night or occasionally at any altitudes, may need a refill only once a year, if that.

If you're still on the fence about buying an oxygen system—and if you don't fly above 8000 or 10,000 feet or at night much—we still recommend a pulse oximeter. These have evolved since we last evaluated them in 2005, and the prices have plummeted to under $50.

What you pick in portable oxygen depends on how frequently you use it and at what altitudes you're likely to fly. The former has to do with tank size and the latter whether you'll need masks for cannulas or both. Another option is an oxygen generator that, while much more expensive, has the advantage of being always available with no fear of running out when you most need it. (See the sidebar on page 17.)

PORTABLE SYSTEMS

The basic portable oxygen system consists of an oxygen bottle, a regulator that reduces the pressure of the compressed gas from the 1800 to 2100 PSI range (depending on the bottle) to a usable range, some sort of flow control device and flow meter, tubing and either an oxygen mask, standard cannula or a type of conserving cannula, of which the Oxymizer is most common.

A conserving cannula "rebreathes" a portion of the oxygen via a small bladder either in a plastic moustache device or pendant arrangement on the cannula. The conserving cannula uses about a third of the oxygen of a regular cannula or mask.

The FAA requires using a mask instead of a cannula above FL180. Most of the suppliers provide only one mask with each system, something that puzzles us as basic masks aren't that expensive and would allow you to operate above FL180 on a flight, plus you may have a passenger or two unable to breathe through their noses.

If you've ever used a mask, you have some inkling of why people sometimes ignore the 18,000-foot guidance for cannulas. Masks are generally less comfortable and they're awkward to use. But our tests of masks versus cannulas show that for normal breathing, masks do a better oxygenation job.

BOTTLES

Oxygen bottles are available in a wide range of sizes, capacities and weights. For the purpose of this article, we looked at systems with the 22-24 cubic-foot models (some suppliers did not have one or the other) because they provide enough oxygen for an extended round trip without refilling and can be wrestled in and out of the airplane without Herculean effort.

Although suppliers have similar selections in cylinders, they can obtain other sizes in most cases. These range in size from minimal 6-cubic foot A cylinders to 33-CF tanks that will keep

An inexpensive pulse oximeter, right, will quickly show the oxygen saturation of your blood so you can decide when you need supplemental oxygen such as the basic, one-person system from Aeromedix, above right.

20-22 CUBIC-FOOT O2 SYSTEMS

SUPPLIER	FLOWMETER?	MASK OR CANNULA?	2-PLACE PRICE	4-PLACE PRICE
AEROX	INDIVIDUAL FLOWMETERS	OXYSAVER CANNULA AND 1 MASK	$609	$823
MOUNTAIN HIGH	INDIVIDUAL FLOWMETERS	CONSERVING CANNULA AND 1 MASK	$635	$795
AIR KING	2-PLACE BASIC USES SINGLE REGULATOR, 2- AND 4-PLACE *PRECISE* USES INDIVIDUAL FLOWMETERS	REGULAR CANNULA AND 1 MASK	BASIC-$425, *PRECISE*-$450, WITH OXYMIZER CANNULA-$500	$550, WITH OXYMIZER CANNULA-$650
AEROMEDIX	2-PLACE BASIC USES SINGLE REGULATOR FOR FLOW CONTROL, 2- AND 4- PLACE ADVANCED USES INDIVIDUAL FLOWMETERS	OXYMIZER CANNULA AND 1 MASK	BASIC-$365.95, WITH FLOWMETER-$495	$730
PRECISE FLIGHT	INDIVIDUAL FLOWMETERS	SAME NUMBER OF MASKS AS CANNULA	$695	$795
SKY OX	PILOT CONTROLS FLOW FOR ALL USERS	OXYMIZER CANNULA AND 1 MASK	$550.40	$620.40

four people perking along for six hours at 18,000 feet. Obviously, buy the size that suits your trip profile.

Regulators reduce the bottle's high pressure to something that the flow meters and dispensers can handle. These can be adjustable or fixed. The advantage of adjustable regulators is that the flow can be bumped up when two or more users are on the system, causing uneven oxygen delivery. Regulators are also set up with either two or four user outlets. Some smaller systems may have just one. Again, buy what you need.

Flowmeters for oxygen systems are rotameter-type designs, sometimes called floating-ball meters. They consist of a clear plastic tube with unmetered (but pressure-reduced) flow entering one end and metered flow to the mask emerging from the other. The flow is adjusted via a thumbscrew needle valve that suspends the ball in the plastic column corresponding to a scale calibrated in altitude.

There are two common types of flowmeter, the A-3 and the A-4. The A-3 is designed for use with the industry-standard Oximizer conserving cannula, while the A-4 can be used with either a cannula or a mask.

Precise Flight offers the A-5 flowmeter, which is an improved version of the A-4 that's suitable for masks and cannulas. Aerox has its own flowmeter design called the Glow-Meter. It glows in the dark to make tracking the flow at night easier.

Some suppliers include carrying cases with their portable systems, some price them as extras. While a carrying case allows slinging the oxygen cylinder to a seat back, they do cost about $50 and we note that users put the bottles in a number of locations, so saving a little off the price in return for no carrying case makes some sense. We priced two- and four-place systems. In doing so, we noted that some companies offer a basic two-place system targeted toward the occasional user at some attractively low prices.

Flowmeter allows the user to set and monitor the flow of oxygen.

AEROX

Aerox is the most expensive of the suppliers we surveyed. Typically, their systems include individual flowmeters so each person can select the appropriate flow via a dedicated meter. They list quite a range of cylinders for their systems, from the smallest A to the largest F. Carrying cases for the Aerox system will fit most of these cylinders, although not all of them. The bottle fits into a sleeve like carrier which then zips up.

The regulators are equipped with push-pull connectors which simplifies plugging users in or remove users. It also allows you to disconnect the hoses to sort through tangles. Aerox also offers a nice little fixed flow system called the EMT-3. The company says it will last about 25 minutes at 25,000 feet and would be an excellent emergency system.

MOUNTAIN HIGH

Mountain High has one of the most sophisticated and complete oxygen equipment lines in aviation and sells everything from fittings to oximeters to full systems. Some years ago, it developed a clever electronic pulse-demand oxygen conserver that dramatically reduces oxygen consumption at the expense of a bit of cockpit clutter.

MH sells compete systems, with carrying bags, regulators and dispensers. In the four-place market, MH's systems are toward the top tier and we think it has one of the best-designed regulator systems in the business.

The regulator has four ports, which have snap-in connectors that exit the top. In a four-place system, this helps organize the tubing, since they all exit the top of the cylinder in the same direction. Further, you can easily expand it to three- or four-place down the road by just adding tubing, flow meters and cannula.

AIR KING

Air King, also known as Delta Oxygen Systems, has a basic, two-place portable system—which it calls Advanced—with standard cannula and no individual flow control for a reasonable price of $425. It's a good basic, starter system in our view. From there, you can step up into the Oxymizer cannula and individual flow control. It also calibrates its flow meters in liters per minute, which allows for a rapid bit of math, knowing the capacity of the oxygen cylinder, to determine the endurance at the present rate of use.

Air King also sells what it calls an oxygen headset, which uses an over-the-head band to support a nasal cannula, rather than the usual around-the-ears arrangement. Air King has both standard cannulas and a simple mask without a mic.

ROLL YOUR OWN OXYGEN

If you want a portable oxygen system but don't want to be bothered with having to refill an oxygen cylinder or risk being out of oxygen when you need it, a portable oxygen generator may be perfect. Inogen makes a generator that pressurizes ambient air and separates out the oxygen, which it sends to you as you demand it by breathing through a cannula.

The downside is that this is a single-place unit. Currently, there is no way for it to supply additional breathers. Power for the unit comes from either 12-volt ship's power or a battery pack. The price, ranging from $2600 to just short of $3000, depending on the supplier, is steep. enough to give one pause, especially when a two-place portable unit can be had for $400.

AEROMEDIX

AeroMedix also offers a basic, two-place portable system at a rock-bottom price, $365.95, which includes Oxymizer cannula. It makes use of a simple splitter to provide oxygen to two people, but, as with Air King, there is no individual flow control. Adding two of its proprietary, acrylic flow control flow meters bumps the price to $495.

We like the AeroMedix flowmeters; they're as robust as we've seen and not likely to get broken if someone inadvertently kicks one.

PRECISE FLIGHT

Precise Flight bought out Nelson Oxygen, one of the innovators in the world of portable aviation oxygen. It takes the approach that individual flow control is needed even at the most basic level and also seems to be the only company that provides the same number of masks as it does cannula with each system. Its A-5 flowmeter is a variable area flowmeter, which is a tapered tube, vertically positioned with the large end at the top, and allows visual monitoring of the volume of oxygen flow. It is a dual-scale flowmeter, one is for use with face masks and standard cannula, and the other is used for oxygen-conserving cannula.

SKYOX

SkyOx believes that the pilot should be in control of the rate that oxygen is used, keeping tabs on consumption and the amount remaining, rather than allow each user to just suck up the tank. The SkyOx system comes with its own adjustable-flow regulator and gets rid of individual flowmeters in each line. Its systems include Oxymizer cannula.

SkyOx also offers the Bandit quick-donning headset which has the nasal cannula attached to the headset via a boom arrangement similar to the boom microphone.

CONCLUSION

As pulse oximeters have provided data for an individual to determine the need for oxygen for rational thought and safe operations, we are pleased that there a large selection of portable systems on the market. If you are looking for a basic system to provide supplemental oxygen to you and one other person, the AeroMedix price looks attractive to us.

For a four-place system, we think the prices are all reasonable, there is a wide range of choices, and personal preference is going to play a big role in making the selection. We advise looking over the websites carefully and then calling the companies in which you are interested to get more details. We found that each one was more than willing to answer all of the questions we had and were intimately knowledgeable about their systems.

CONTACTS

Aerox
207-637-2331
www.aerox.com

Aeromedix
888-362-7123
www.aeromedix.com

Air King
866-737-7247
www.deltaoxygensystems.com

Mountain High
800-468-8185
www.mhoxygen.com

Precise Flight
800-547-2558
www.preciseflight.com

Sky Ox
800-253-0800
www.skyox.com

Renter's Insurance Low Time = Low Limits

The Catch-22 for anyone renting aircraft and seeking significant insurance coverage is you can't get the coverage until you build the time.

by Jeff Van West

While it's easy to peg GA's continuing decline on rising avgas prices or threadbare FBO aircraft, the reality is more diverse. It's a "death by a thousand cuts," where cost and the fleet are major wounds, but free time, demographics, and a score of other factors play in.

One of the nicks is insurance. Specifically, there's a hole that may be swallowing up exactly the kind of new pilots who could breathe some life back into the industry: moderate-net-worth individuals with low pilot time.

These are folks with the financial resources to rent aircraft regularly, and probably step into ownership or shared ownership, but who could be completely devastated financially by a serious lawsuit after an accident.

We heard from one 63-year-old, 220-hour pilot who said, "I would not drive with only $100,000 liability coverage, so it makes no sense to fly with that little either. I've tried several insurance companies, but no one will consider higher limits for a renter, or even an owner with under 500 or 1000 hours."

HOW MUCH IS ENOUGH?

What insurance you really need and whether or not you can buy it is a matter of divergent opinion. Mike Adams, Vice President of Underwriting for Avemco, says that more liability coverage isn't popular.

"Our experience has been that even when we did offer bodily injury limits greater than $100,000, very few pilots purchased it. Essentially we were putting our entire non-owned premium at risk for one or two high-limit policies.

Our experience has also been, the higher the liability limit, the greater the claim settlement amount. This fact was borne out by a study of our claims where we were able to identify similar injuries and property damage with claims that had different limits of liability."

Jon Doolittle, owner of Sutton James Insurance Brokers, generally agrees. "Whatever limits people have is what the lawyer will settle for. It's pretty rare that it goes past that."

But "rare" isn't "never," and Doolittle says that if you can get more than $100,000 in liability, it's worth going after just to have sufficient coverage for the cost of defense. This is where "per seat" limits matter and factor into who you take with you in the air.

CHECKLIST

Most, not all, cases settle for whatever the liability limit is, even if low.

Ownership, or some clubs, may offer access to better limits.

Higher limits are virtually unavailable to renters or low-time pilots.

SUBLIMITS

If you have $1 million liability coverage and plow through someone's wheat field and barn, the entire million is potentially available for payout. However, if you had a passenger with you, payout to that passenger is limited. This is typically $100,000 per person, although a flood of new insurers entering the market in the past couple of years has made $200,000 limits more common. Policies without this restriction (so-called "smooth" policies) are virtually unavailable to renters or low-time owners in some aircraft.

It's a rental. Are you insured? After the accident is not the time to find out.

Of course, this is just looking at liability to passengers or property on the ground. Renters must pay extra for non-owned hull damage if they might be sued for the cost of the damaged aircraft. This could add well over $1000 to a policy for $100,000 of hull coverage for low-time pilots.

But you might not need that much. A rental agreement should specify a limit of your responsibility for aircraft damage. If your share is only the FBO's deductible, that's all the coverage you need.

This gets sticky if you borrow a friend's airplane. In the absence of a written agreement otherwise, brokers tell us a court is likely to assume you are responsible for returning the aircraft in the state you borrowed it.

This may be true even if you meet the approved pilot status on the policy, unless you can get the owner's insurance company to provide a waiver of subjugation—a promise that after they pay the owner's loss, they won't come after you for the balance.

Even if you're on the hook for the entire aircraft, a lesser amount of non-owned hull may still protect you. Your renter's insurance company should require a release of further liability before they pay. So if you total a $100,000 airplane and have $50,000 non-owned hull, your buddy's insurance company may take the $50,000 and settle, rather than trying to get the full $100,000 in court with your renter's insurance company defending you.

We asked Doolittle what someone should do who isn't comfortable with only $100,000 liability and partial hull coverage protecting their assets even with an unlimited defense fund. "Beats me," he said. "You cross your fingers or you buy an airplane."

PARTNERSHIPS AND CLUBS

The situation changes somewhat when looking at ownership. The underlying question underwriters ask is how well the pilot is suited to the aircraft. A low-time, VFR-only pilot owning a basic single such as a Cessna 172 or Piper Archer can usually get $1 million smooth for as little as $3000 a year.

MINIMAL SUBLIMITS PROTECTION

The good news is that tort reform worked. The bandwagon to put limits on lawsuits that got rolling about 25 years ago resulted in federal and state laws that have reduced the number of aircraft crash cases dramatically. You've seen it in insurance premiums that have stayed the same or dropped over the last 15 years as more companies are now willing to write aviation coverage.

The bad news is that if you crash and are sued, the odds are roughly 80 percent that if you were the pilot, the accident was your fault and $100,000 doesn't buy what it did 40 years ago when sublimits policies became popular.

It's essential to think of an aviation liability insurance policy that has sublimits for what it really provides you: the cost of a defense lawyer—which can be *staggeringly* expensive—and $100,000 (the most common sublimit amount) to pay any one person who is hurt as a result of the accident.

You may think you have a $1 million dollar policy, but if it has sublimits, that means it really is a series of small policies that can add up to a million bucks.

If you're flying a two-place airplane, there is only $100,000 available to pay for the injuries to your passenger. You'd have to really screw up and hit nine more people in the crash before the full million of the policy could ever come into play.

The question to ask yourself is what level of risk is acceptable to you? If you're a broke college student working on your ratings, why carry insurance at all? If you have the financial wherewithal to own an airplane, you may have some other assets that can be at risk. It's essential to evaluate your finances, your type of flying and risk comfort level.

The most likely accident you face is either pressing on VFR into weather, which is almost always fatal, or losing control when landing in a crosswind, which usually means a bunged-up airplane and some broken bones, if that.

Let's say you do decide to scud run and crash. Your airplane only has seatbelts, so although you and your passenger survive, the impact renders both of you dysfunctional. Then the fire starts. You both die as a result .

The defense attorney hired by your $100,000 sublimit policy will be the one to tell your spouse that s/he and the kids may face poverty because that $100,000 wasn't even close to enough to settle the lawsuit and your assets are in play.

If you have assets of any sort, spend some time with your insurance broker and an aviation lawyer (the AOPA has names in your area) discussing how to protect yourself. It may be with a "smooth" (no sublimits) policy.

You may want to see if you can get more than $1 million coverage. No, it doesn't make you a target for lawsuits. You have to crash before it matters and then it buys you peace of mind.

If you can only get a sublimits policy, you may be able to get more than the basic $100,000. Such policies exist; a good insurance broker can help find what's out there.

If you can only get low sublimits and have assets, consider not carrying passengers.

No matter what, if you are at all concerned about protecting yourself from post-crash litigation, one of the most effective things you can do is take a flight review every six months, just as the pros take a six-month checkride.

Those who take regular recurrent training, especially if they stay current in the FAA's WINGS program, are significantly less likely to have an accident than those who just do the minimum requirement of a flight review, biennially.

—Rick Durden

COVERAGE	ANNUAL PREMIUM AND NOTES
RENTER'S INSURANCE—$1 MILLION LIABILITY/$100,000 PER PERSON	$219
RENTER'S INSURANCE—$1 MILLION LIABILITY/$200,000 PER PERSON	$525
RENTER'S INSURANCE, $1 M LIABILITY, SMOOTH (NO SUBLIMITS)	NOT A CHANCE
ADD $5000 OF NON-OWNED HULL COVERAGE	$90
ADD $250,000 OF NON-OWNED HULL COVERAGE	$1900
OWN A $45,000, 1968 CESSNA 172	$1449 FOR 1M SMOOTH, $2800 EACH FOR ADDITIONAL $1M
OWN A $120,000 2005 CESSNA 172SP	$1440 FOR $1M SMOOTH, WITH ADDITIONAL $1M $2600 EACH
OWN A $250,000 2006 CIRRUS SR22	• $4125-$5875 FOR $1M/$300K PER SEAT • $6850 FOR $1M/$100K PER SEAT • $7500 FOR $1M SMOOTH • NO EXCESS COVERAGE AVAILABLE
OWN A $900,000 2006 PIPER MERIDIAN TURBOPROP	• $11,250 FOR $1M/$100K PER SEAT AND DUAL ONLY FOR ONE YEAR • $16,000 FOR $1M/$100 K PER SEAT AND DUAL ONLY FOR ONE YEAR, HOWEVER, $1M SMOOTH MAY BE AVAILABLE WITH RIGHT MENTOR PILOT. • NO EXCESS COVERAGE AVAILABLE

The chart above shows real-world numbers for a 220-hour private pilot with an instrument rating. This assumes a clean loss history and acceptable pilot age. Data courtesy of Chris Arnold of Sutton James. (See www.suttonjames.com)

Put that same pilot in a Cirrus SR22 and half the companies won't underwrite him until he gets 500 hours total time and an instrument rating. A few will write, but require an instrument rating within a set number of months.

None will allow $1 million smooth until 50-100 hours of time in type. The numbers for turbines are often much higher—$5 million and high or smooth sublimits are common—but requirements such as mentor pilots factor into the equation.

As your total time and, more importantly, time in type build, your options get better. Doolittle points out that pilots trying to move directly to high-performance aircraft with low time must prioritize. The three factors are: coverage, cost and crew.

For example, you can often get the high limits but for a stiff price and only with a mentor pilot in the right seat. Or you can go solo, but your limits will be low and the cost high. After a year, you might get two out of the three factors in check. It might be another year before you get the complete package.

Flying clubs generally get insured at the experience level of the least-experienced pilot. But there are exceptions. Read the policy.

For partnerships, the magic number is five. At five or fewer pilots per aircraft, "pleasure and business" rates apply and what is close to the rate one pilot would pay is divided by five. Rates for six to 10 owners per plane can be two to four times as high. More than 10 owners and most underwriters pass.

OTHER CATCHES

Underwriters and brokers tell us they often have the sad task of telling potential owners that their umbrella policy almost certainly excludes aviation. Some pilots with life insurance that includes aviation tell us they are simply betting they die in any wreck severe enough to injure passengers. We're not sure this counts as sound fiscal planning.

Another factor is who your passengers are. If you almost always fly alone, per-seat limits are of little consequence. Employees of your company flying with you are also usually excluded from any aviation policy, as company insurance is supposed to cover them on the job. This could be a serious catch with high-worth employees where $1 million wouldn't begin to cover the total payout. If this is a concern, some companies specifically offer add-on liability coverage.

With about 22 companies competing in a market occupied by only seven a decade ago, an old issue might return and you should watch for it. Some states allow the insurance companies to walk away from your defense once they've offered their total indemnity—so long as it was stated somewhere in the policy's fine print. Make sure your policy has no escape clause where your carrier can be released from their duty to defend before a final agreement has been reached.

HOW BIG A PROBLEM?

Is this issue driving away pilots? Jason Wissmiller, a co-owner of Regal Aviation Insurance, doesn't think so. "I hear people saying they wish they could have higher limits, and we do what we can for them, but I've never had someone tell me to cancel a policy because they were selling their plane because they couldn't get higher limits." He also echoed that most owners don't opt for higher limits even when the price delta is only $200-$300 per year.

We think it's not a huge issue, but it has some legs. We've also heard anecdotally about good flight instructors leaving the fold for essentially same reason: They don't feel any available insurance can cover their ongoing liability for students they've trained. In the end, it really comes down to acceptable risk. As Doolittle puts it, "My view is you buy the highest you can and go fly. Life's too short."

Jeff Van West is Aviation Consumer's *former managing editor.*

The avionics in this Piper Aztec are put to the test on an RNAV approach, before its owner flies it home from the shop. Good shops provide customers with basic operational demonstrations during this testing.

Retrofit Checklists: Test-Flying, Familiarity

Retrieving an aircraft from the shop after major avionics work requires a meticulous preflight, flight-testing and a solid understanding of the interface.

by Larry Anglisano

The fragile relationship between avionics shops and aircraft owners is sometimes stressed at the end of a project. That's partly because some owners have unrealistic expectations, assuming the aircraft will be released right after a flight test.

On the other hand, shops create stress for themselves when they over-promise and offer the impression that work on the aircraft is finished when in reality, it might still require testing, tweaking and more work following the flight test.

You can avoid this stress, while increasing safety, by approaching the delivery process with the proper mindset. This includes crafting your own delivery checklists of items to look for before, during and after the shake-down flights with the new equipment. You can also make the delivery process easier by studying how to operate the new equipment, working closely with the shop during the project and not scheduling important trips until you are certain everything works the way it should.

PLANNING THE PICKUP

You can plan the delivery process early. Good shops will gather pilot guides and training material for the new equipment and offer them to the customer well in advance of delivering the aircraft. This is a productive way to pass the time while the aircraft is down. The goal is to become familiar with the equipment's operation so you can effectively and safely fly the aircraft on the test flight. You'll find that some pilot guides are more concise than others.

Your early studying might present a challenge, since you won't have the real equipment to work with as you follow along with the manual. Manufacturers such as Garmin, for example, recognize this and supplement the GTN-series navigator manual with a training CD. We think the operating manual for the Aspen EFD1000 display is well-written, presenting real-world flight scenarios, while covering system functionality in detail. Garmin presents similar scenarios in their manuals.

DELIVERY DAY

Next on the checklist should be the timing of the delivery. If you can avoid it, don't retrieve the aircraft from the shop—especially when the delivery requires a flight test—when you are short on time. Shop schedules vary, but most shops won't want to begin flight testing late in the afternoon, in case there are repair issues that need to be addressed. Remember, a flight test is just that—a test of the equipment. There's no guarantee that you will fly the aircraft home that day. You'll set yourself up for disappointment if you expect otherwise, and you'll be pleased if you can take it home that day. If the shop performs thorough ground testing, there should be few,

CHECKLIST

Methodical delivery checklists add safety and efficiency to a project.

Avionics work can disturb wiring and existing systems. Be ready for failures.

Flight testing is a risky stage in major retrofits, creating insurance issues.

Be sure to check critical systems including autopilot disconnect and pitch trim operation.

if any, problems to address once they pull the trigger on a fly-off.

Plan on performing the flight test during day VFR conditions. Many shops have stringent requirements written into their Repair Station manual, which covers the conditions for which they can conduct maintenance flying. You might need to make an honest assessment of your currency. If the aircraft was down for weeks or months, are you confident that your skills are sharp enough to handle the workload that tags along with maintenance flying? The technician you are flying with will be well aware—and apprehensive—of this additional risk. Consider logging some takeoffs and landings before carrying the technician as a passenger.

SHOPS AND TRAINING

Your delivery checklist should include a solid plan for obtaining quality avionics training. Most avionics shops aren't in the flight training business. The better shops have people on staff who have exceptional product knowledge and know how to operate the equipment in the real world. These people often mentor the customer and will likely fly shotgun on the flight test. But this doesn't make them flight instructors, and it doesn't make them responsible for training customers.

If you don't feel you are up to the task of flying the aircraft after major avionics work—particularly on a maintenance flight test—we think the best option is to put your piloting pride aside and hire someone to take your place. But as our sidebar describes, there are important insurance issues to be considered. To be clear, a maintenance flight-test is not to be considered a training flight.

ALL EYES ON PREFLIGHT

You should craft your own walk-around and cockpit preflight checklist to accomplish as you prepare to fly. Approach this with a skeptical mind-set, especially if there was maintenance work accomplished in addition to the avionics work. The exterior walk-around should have you looking for properly secured cowlings, inspection plates and any securing hardware that might be missing or loose. Turn on all of the exterior lighting—systems that are easily missed during a walk-around but susceptible to failure after a large teardown. While you're at it, check the stall warning horn.

Pay particular attention to the pitot tube and static ports. If there was pitot and static system testing that took place, it's not uncommon for technicians to tape the ports to pressurize the static system. Hasty techs forget to remove the tape. Since the aircraft has probably been sitting for a while, look hard at fuel samples—and fuel quantity.

Since the shop likely performed sizeable amounts of ground running, don't assume the tanks have the liberal amounts of fuel they had when you dropped the aircraft off. One technician we spoke with had a chilling tale of dealing with fuel exhaustion on a flight test—and with a frazzled owner who swore he had enough when he dropped the aircraft at the shop.

Paperwork is an important and sizeable part of major retrofits. Ask the shop to go over all of the paperwork they revised and produced in support of the installation. This should include updated weight and balance reports, equipment list revisions, flight manual supplements, FAA 337 paperwork and updates to pilot operating manuals. Make

DELIVERY CHECKLIST

- ✔ Study new pilot guides prior to the flight test.
- ✔ Reserve plenty of time for a VFR pick-up.
- ✔ Decide who will pilot the flight test, if required.
- ✔ Deal with finances in advance of delivery.
- ✔ Review supporting paperwork.
- ✔ Verify fuel status, check exterior lighting.
- ✔ Check fasteners, access panels, hardware.
- ✔ Test autopilot and pitch trim system.
- ✔ Review circuit breaker arrangement and switches.
- ✔ Acknowledge, resolve databus error messages.
- ✔ Verify that a fire extinguisher is on board.

sure the aircraft registration, flight manual and airworthiness certificate are in the aircraft.

WHAT WORKS?

Your cockpit checklist should include testing critical items. The first area you might look at is the circuit breaker panel and bus-tie configuration. A circuit breaker may be the only way to remove power from a new system and you should know exactly where it is. Speaking of power and electrics, check that the fire extinguisher is in the aircraft. This and other cabin accessories are often removed for storage during the installation.

If the aircraft is equipped with an autopilot and electric pitch trim system, follow the manufacturer's procedures for preflighting the system. These procedures should include servo disconnect, proper pitch trim movement and correct control surface drive. Make a methodical sweep from one side of the panel to the next, checking instrument panel and cabin lighting, testing annunciator lamps, while becoming familiar with newly installed switches and controls. Power up the avionics and look for system warning messages that may point to failing data ports and databus errors. These errors indicate communication problems between interfaced equipment. You might be able to check for valid and accurate Mode C altitude reporting, if the transponder displays pressure altitude.

For the flight test, the tech likely has a plan for testing the interface. A maintenance flight test should preclude with a briefing that establishes who is going to do what tasks during the test. Let the technician evaluate the equipment and push the buttons while you manage the aircraft and watch for traffic. In general, flying a few instrument procedures along with reasonable amounts of cruise flight should be sufficient to test the entire suite. You'll be testing comm radio performance, navigation system accuracy, autopilot coupling, heading system accuracy and other items that are spelled out by a given manufacturer's testing procedures. Experienced techs know what to look for. When you make arrangements to pay your bill, keep in mind that money matters can be one of the biggest source of stress between shop and customer. This can be avoided with good communication If the shop presented you with payment terms that include payment upon delivery of aircraft, it's expected that you show up with payment. As much comradery that may exist between you and your shop, don't forget that the shop is still there to make a living.

Deal with the financial part of the work before the flight testing so it doesn't distract from the delivery process. Last, flying behind a retrofitted panel could be like flying a different aircraft. Be ready to overcome a learning curve before you tackle complex missions.

PRE-FLIGHT YOUR INSURANCE FIRST

While most post-installation testing, system calibration and software setup can be accomplished on the ground with test equipment, there are certain operational checks that can only be verified in flight.

Moreover, product installation manuals often govern the requirements for return-to-service flight testing. The short list includes checking autopilot approach coupling, checking for RF interference, verifying the accuracy of traffic alert systems and checking engine monitors and fuel totalizers. Plus, flight testing provides the shop a real-world assessment of the avionics suite as a whole, something that just isn't possible on the ground.

Let's make one thing clear—maintenance flight testing is serious business that can be risky. It requires a certain level of piloting skill and product knowledge, and all the while, the safety of you and the shop technician rides in the balance. Many avionics techs we've spoken to over the years admit to some tension when it comes to flying with pilots they don't know. We feel their pain.

In the bad old days, many shops would take care of the flight testing on their own—often flying the aircraft before the owner showed up for the delivery. That's a bad practice, and it has all to do with liability and insurance issues. We spoke with our insurance pro, Jon Doolittle from Sutton James Aircraft Insurance, for his guidance. He strongly advises owners to fly the aircraft while a shop representative tests the equipment from the other seat. This is generally how it works, but there are exceptions.

If you offer up the aircraft for the shop to fly without you being present—or if they hire a pilot to fly it on your behalf— you need to make certain the pilot meets the minimum requirements in your insurance policy.

You should provide the shop with a certificate of insurance, which describes the coverage in effect and also includes the shop and the pilot as additional named insureds under the liability coverage. The coverage should include a waiver of subrogation with respect to physical damage to the airplane. This waiver is a promise from the owner and from his insurer not to come after the shop for damage that they cause to the airplane while doing the test flight. If the pilot doesn't meet the minimum requirements, neither the shop nor the owner will be covered for the test flight.

If the shop carries non-ownership liability, including non-owned physical damage coverage, they'll still need to make sure they meet the owner's insurance requirements.

Be sure to work out these details in advance of pulling the trigger on a flight test, and ask if in-flight testing is even necessary for the work done. Last, don't assume the shop will—or won't—fly your aircraft.

Diamond DA40 Star

With an astonishing safety record, the pleasant-handling Diamond Star has established a reputation as reliable, fast and efficient.

We've watched the evolution of the Diamond DA40 series with interest. Our first reaction to what would become the Diamond Star was to be less than impressed. We thought the canopy was a marketing ploy that would make emergency egress difficult, and the cabin looked small and uncomfortable.

Then we flew it. The canopy provided superb visibility, the speed was impressive—newer models are even faster—and handling was just plain fun. We liked the control harmonization and how easy it seemed to be to land in a crosswind.

The cabin proved to be roomier than it looked with control sticks instead of panel-blocking yokes, even if they did have to be used with the wrong hand.

Given its European roots, Diamond came at the DA40's design as sort of hybrid between the sleek glass gliders the company started out producing when it was Hoffman Flugzeugbau and more traditional aircraft U.S. customers are accustomed to. This yielded what we think can fairly be called a world airplane.

HISTORY OF THE LINE

Hoffman Flugzeugbau began life in 1981 in Friesach, Austria, producing the H36 Dimona motorglider, a popular recreational airplane in Europe. Ten years later, Christian Dries and family took over Hoffman and in 1992, it launched an effort at the North American market by opening a new plant in London, Ontario, in a converted World War II aircraft factory.

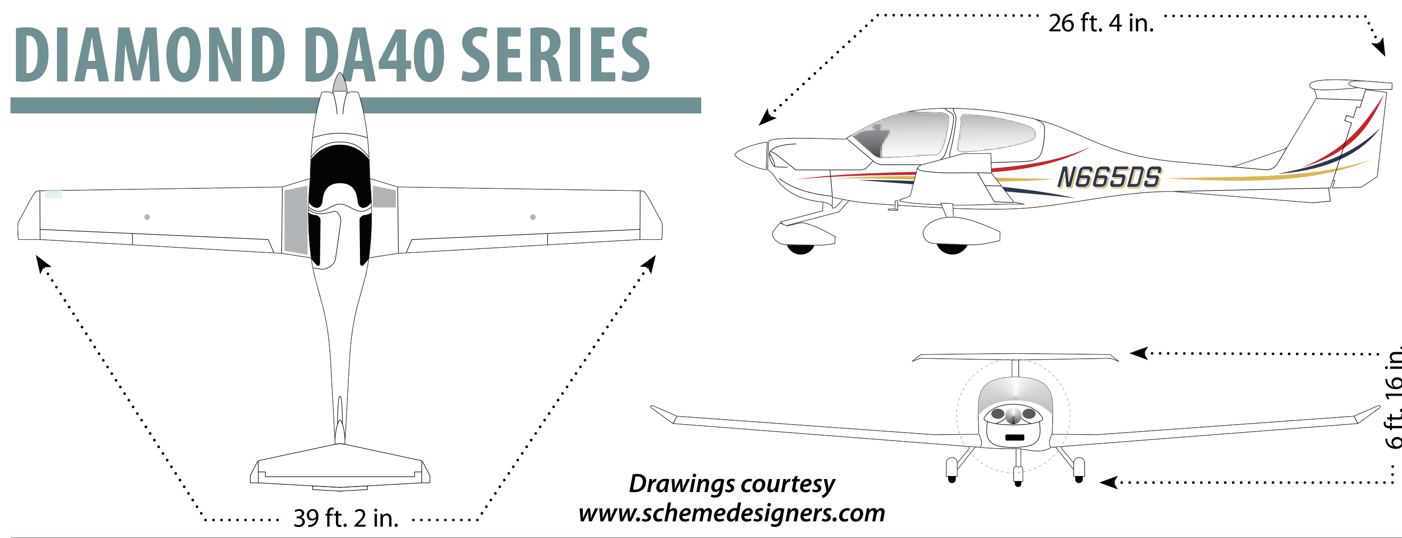
> *The canopy provides superb visibility, the speed is impressive and handling is just plain fun.*

Diamond—then called Dimona—got its feet wet in the U.S. market by importing the Austrian-built DV20 Katana. In 1995, it began building Rotax-powered DA20-A1s in the London plant and selling these into what was then a lukewarm market for new trainers. By the time the company changed its name from Dimona to Diamond in 1996, it realized that both the North American and world markets had room for a composite four-place airplane.

In 1997, Diamond announced the DA40 Diamond Star at the big European show in Friedrichshafen, Germany, with the prototypes powered by the Rotax 914 and Continental IO-240. But the airplane clearly needed more power. In 2000, the DA40-180 was certified with the Lycoming IO-360 and a year later, production began in the London plant.

Sales were initially brisk, especially to the trainer market which, increas-

DIAMOND DA40 SERIES

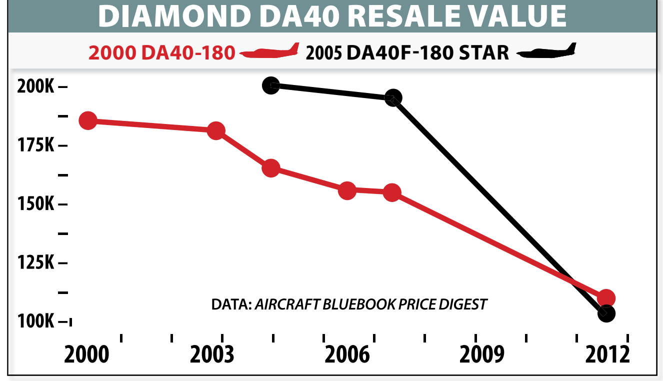


Drawings courtesy www.schemedesigners.com

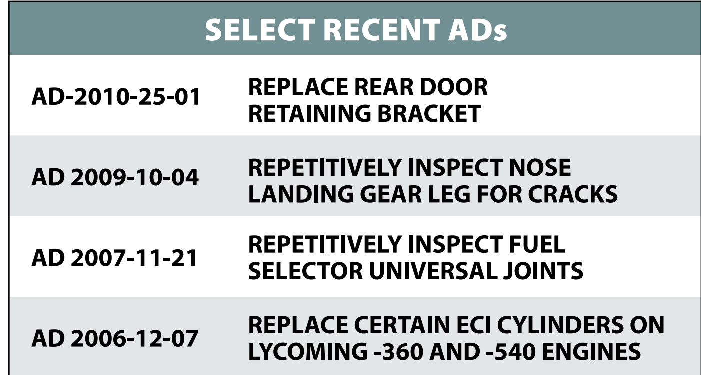
DIAMOND DA40 STAR SELECT MODEL HISTORY

MODEL YEAR	ENGINE	TBO	OVERHAUL	FUEL	USEFUL LOAD	CRUISE	TYPICAL RETAIL
2000 DA40-180 STAR	LYCOMING IO-360-M1A	2000	$25,000	41	915 LBS	145 KTS	±$110,000
2004 DA40-180 STAR	LYCOMING IO-360-M1A	2000	$25,000	41	915 LBS	145 KTS	±$130,000
2005 DA40-180 STAR	LYCOMING IO-360-M1A	2000	$25,000	41	915 LBS	145 KTS	±$135,000
2005 DA40F-180 STAR	LYCOMING O-360-A4M	2000	$25,000	41	915 LBS	135 KTS	±$105,000
2006 DA40-180 STAR	LYCOMING IO-360-M1A	2000	$25,000	41	915 LBS	145 KTS	±$150,000
2006 DA40F-180 STAR	LYCOMING O-360-A4M	2000	$23,000	41	915 LBS	135 KTS	±$110,000
2007 DA40F-180 STAR	LYCOMING O-360-A4M	2000	$23,000	41	915 LBS	135 KTS	±$120,000
2007 DA40-XL STAR	LYCOMING IO-360-M1A	2000	$25,000	41	915 LBS	145 KTS	±$210,000
2011 DA40-XLS STAR	LYCOMING IO-360-M1A	2000	$25,000	50	860 LBS	150 KTS	±$324,000

DIAMOND DA40 RESALE VALUE

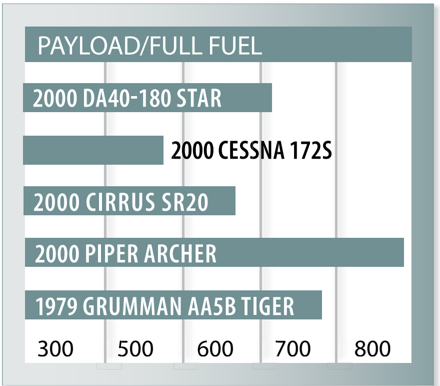


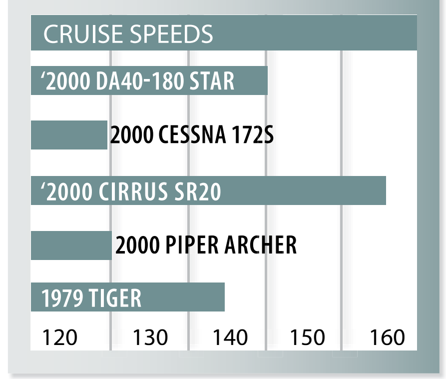
SELECT RECENT ADs



AD-2010-25-01	REPLACE REAR DOOR RETAINING BRACKET
AD 2009-10-04	REPETITIVELY INSPECT NOSE LANDING GEAR LEG FOR CRACKS
AD 2007-11-21	REPETITIVELY INSPECT FUEL SELECTOR UNIVERSAL JOINTS
AD 2006-12-07	REPLACE CERTAIN ECI CYLINDERS ON LYCOMING -360 AND -540 ENGINES

SELECT LATE-MODEL COMPARISONS





PRICE COMPARISONS

2000 DA40-180 STAR ($110,000)
2000 CESSNA 172S ($98,000)
2000 CIRRUS SR20 ($90,000)
2000 PIPER ARCHER $105,000)
1979 TIGER ($49,000)
20K 50K 80K 110K 140K

Front seat room is adequate even for taller pilots such as owner Jim Siverts (above). Early Stars offered a small baggage area and tube for larger items (left). The baggage area was later redesigned to include fold-down rear seats.

ingly, was turning to Cessna 172s for new training aircraft. Many flight schools found would-be students weren't as price-sensitive as they once thought and wanted the option of two additional seats, which the Katana couldn't provide. When it initially appeared in the 2000 model year, the DA40 sold for $189,900, typically equipped.

Initial deliveries of DA40s were equipped with dual Garmin GNS430s and Bendix/King KAP140 autopilots. In 2004, Diamond announced that new Stars would have the Garmin G1000 EFIS system and that same year, Diamond announced a joint venture to sell and build DA40s for the Chinese market, primarily for training in that country's burgeoning airline sector. Knowing it had found a niche, in 2005, Diamond announced the DA40-FP, a fixed pitch-only version of the airplane, with the carbureted Lycoming O-360. This model was aimed specifically at the training market. The FP's base price at the time of introduction was $187,800.

In 2006, the DA40XL appeared, which was basically just packaging of high-end options, such as the Garmin GFC 700 autopilot, Powerflow exhaust system, a composite three-blade MT prop, a 110-pound gross weight increase, electrically adjusted rudder pedals and a premium interior. The airplane was clearly aimed at the upscale owner-flown market, which Cirrus was having good success serving. Fully equipped, the XL model sold for $329,000.

In late 2007, yet more versions of the DA40 appeared, the XLS and the CS. The XLS has a wider, higher canopy and a luxury interior while the CS is essentially an a la carte model with a constant-speed prop that lets flight schools configure it with interiors and other options. The base price of the CS was $259,950, while the XLS base was $334,950, or over $380,000 fully loaded.

CONSTRUCTION

When Diamond bought Hoffman, it paid attention to the company's core expertise: building clean, strong glass structures. This is definitely reflected in the DA40's construction, which is built along the same lines as the two-seat Katana/Evolution/Eclipse series.

The fuselage is constructed of wet layup material in two halves which are bonded together longitudinally, with the vertical stab as part of the assembly. The T-tail is attached separately, as are the wings which, unlike the Cirrus aircraft, are two separate pieces joined at the fuselage center section. The wings themselves are laid up top and bottom in vacuum molds, then bonded together after the internals are installed.

The spar is a massive twin carbon-fiber spar layup between which the fuel is stored in removable aluminum cells. The fact fuel is exceptionally well protected may explain why Diamond aircraft have shown no tendency toward post-crash fires.

The cabin and cockpit is best thought of as a bathtub arrangement with a wraparound canopy in the front and a hinged rear hatch for the backseat occupants. The canopy hinges at the front, rather than the rear, as on the DA20. The rear hatch is on the airplane's left side and is equipped with a pin release for emergency egress. As with most of the modern composite aircraft, the DA40 has spring steel gear and a castoring nosewheel, with steering via differential braking. The gear attach point loads are carried into the center section through attachments on the spar.

Unique among the big three composite lines—Cirrus, Columbia/Cessna and Diamond—the DA40 has center sticks with push-pull rods for elevator and ailerons and cables for the rudder. Rather than sliding seats, the DA40 has rudders that can be repositioned to adjust legroom. Trim is both electric

and manual—there's a trim rocker on the sticks and a center console wheel—and is activated by cables to an anti-servo tab on the horizontal stab.

ENGINES, SYSTEMS

Diamond kept it simple when it came to the powerplant: Lycoming's 180-HP IO-360 has proven reliable and inexpensive to overhaul, at the expense of giving up some smoothness to six-cylinder Continentals. It's also fairly light, an advantage in an airframe as light as the DA40. (Gross weight in early models was 2535 pounds, while newer ones are 2645, compared to 2450 pounds for the Cessna 172 and 3050 pounds for the Cirrus SR22.)

Systems wise, the Star has all the required new-age glitz. The fuel system has right/left/off settings, only one step down from the ideal off/on system for minimizing fuel-related accidents. However, as there have been no fuel-related accidents reported on Diamond Stars in the U.S., we're hardly one to complain. The fuel selector is on the center console. One of the airplane's operating limitations includes a requirement to keep the fuel load balanced.

As is the fashion, the DA40 is an all-electric airplane, with no vacuum system. It has a single starting battery, but also a single alternator, although there's a battery backup for the electric gyros.

One of the DA40's strongest suits is the fabulous visibility afforded by the wraparound canopy; nothing else in GA comes close. But what plastic giveth, plastic taketh away. The cockpit can be boiling hot in the summer, although an opaque shade along the top of the plastic bubble helps. Air conditioning isn't an option in the DA40s; it lacks the power and payload. However, the canopy can be opened during taxi and is equipped with partial-open latches. The heating and ventilation, once airborne, are good. In early models, the panel air vents emitted a noticeable and irritating howl, but this has since been quieted down.

PERFORMANCE, PAYLOAD

When we reviewed the first production model DA40 in 2002, it blew away the competition, mainly the Cessna 172 and 172SP and the Piper Archer, both entry level four-placers. Only the Tiger comes close in older designs, although the Cirrus SR20—also entry

ACCIDENTS: NO NOTABLE PATTERN

As a company, Diamond has one of the most remarkable safety records in all of light aircraft general aviation. In fact, the company's record is so good that it's hard to make much sense of it because so few accidents have occurred.

When we swept the NTSB records for accidents involving the DA40, we found only 10 in the U.S., two of which were fatal. Of the 10 reported accidents, one was a bird strike on a wing in which the flight instructor landed safely, and one involved a safe return and landing after the pilot noticed higher-than-normal engine RPM—it turned out the prop governor had been incorrectly assembled.

Of the two fatal accidents, one occurred on May 11, 2007, when a rented Star was flying at low altitude over a lake in Arizona. The pilot either lost control or unintentionally descended into the water, killing both occupants.

An earlier fatal accident happened in South Carolina, when the pilot of a DA40 commencing an instrument approach evidently descended prematurely and struck power lines, killing all three aboard. Despite the fact that the left wing and engine were severed by the impact, there was no post-crash fire.

In what might be a tribute to the airplane's crashworthiness, another accident probably should have been fatal, but wasn't. It was the classic box canyon trap, where a pilot flew the airplane into rising terrain with converging walls. Unable to climb out of the trap, he crashed into trees, which captured the airplane. Two of the occupants had minor injuries, two had none.

One accident was a garden-variety runway loss of control by a low-time pilot who ran off the runway during a landing, and one was a mid-air in the pattern, which resulted in one serious injury. We know of at least two accidents in the U.K. and Europe—neither fatal—involving engine stoppages of Thielert diesel-equipped DA40s.

With so little data to mine, we examined total accidents versus total registrations. According to FAA records, there are about 700 DA40s registered in the U.S., with six accidents.

By comparison, we found about 800 Cirrus SR20s on the FAA's rolls, with a total of 47 accidents reported in the U.S., 21 of which were fatal. If fatals are expressed as a percentage of total accidents, 44 percent of SR 20 crashes were fatal and 20 percent of DA40 crashes resulted in deaths.

The 44 percent for the SR 20 is nearly identical to what we saw when we looked at its number four years ago—the Diamond number was down by 13 percent. We recognize that the total number of airplanes is not enough to be a statistical universe, however, with over 1300 SR20s and DA40s in the field, the numbers cannot be dismissed.

Over the years, we have noticed that Diamond airplanes show little tendency toward post-crash fires. In fact, we haven't been able to find any significant fires in Diamond airplanes and none in the DA40 series.

That is a remarkable record, largely due to the design of the airplane, which includes placing the fuel tanks between the massive, composite wing spars.

Diamond's competitors have argued that its accident rate is so low primarily because its airplanes are used as trainers. In our view, the use of Stars as cruisers and the legacy of the DA40 series has long ago disporven this assertion.

We think Diamond can rightly claim the best safety record in light aircraft GA.

Diamond flirted briefly with the Avidyne Entegra, but new DA40s have the Garmin G1000.

level—is faster by about 12 knots or so on 20 more horsepower. It easily kept up with the 200-HP Piper Arrow. The early Stars toot along all day on 9.5 to 9.8 GPH at speeds up to about 140 knots. Subsequent models, say owners, are about 10 knots faster and, for the DA40 XLS, Diamond claims a 158-knot top speed with a 150-knot cruise on 10 GPH.

With its long wing and relatively high aspect ratio—reflecting its sailplane heritage—the Star is a terrific climber, even when loaded. Moreover, it leads the league in short-field capability, easily hopping off the runway in 1200 feet or less with a heavy load. At 2535 pounds (2635 for newer models) gross, the Star is light; at 14 pounds per HP, its power loading puts it in the middle of its class. (The Cirrus has power loading of 15.25 lbs/HP, while the Cessna 172 is lower, at 13.6 lbs/HP). Nonetheless, any competent pilot should be able to comfortably operate a Star out of 2000-foot runways, at reasonable density altitudes.

Payload-wise, the Star is really a three-place airplane with baggage space, even at the higher gross weights. Useful loads are in the 850-pound range, although some owners report less. So with the tanks full, it can carry about 600 pounds—three people with some bags. There's a 10-gallon extended-range fuel tank option that further reduces cabin load.

In early Stars, the baggage compartment was a bit of an afterthought, accessible only through the cabin by tilting the rear seats forward. The area itself was quite shallow. This was later redesigned, and now the rear seats fold forward to essentially turn the bacseat into one huge baggage bay.

The Star's weight-and-balance envelope is relatively benign, narrowing a bit toward the gross weight limit. It tends toward forward, rather than aft CG. Offloading fuel is always an option to stuff in more payload, but the airplane carries only 40 gallons usable to begin with, so its range is hardly exceptional. The 10-gallon extended range option helps, but owners complain it narrows the CG envelope, something that needs watching.

The newer XLS models come with 50-gallon tanks as standard equipment.

ERGONOMICS, HANDLING

Entering the Star's cockpit requires hiking up onto the wing and stepping down into the well of the cabin. It's a bit of a practiced art, requiring gripping the canopy's tubular hinges to gain purchase, both for ingress and egress. Not easy, perhaps, but you get used to it.

The rear seat passengers simply step through the hatch and into the rear cabin, which is quite spacious. (Watch the opened rear hatch, though—it's just the right height to bonk an unwary head.)

The front seats don't slide fore-and-aft, although they do recline slightly. A six-foot-five-inch owner reported that, while a little cramped, the pilot's seat has adequate room for him. Rear-seat passengers enjoy adequate footroom, thanks to footwells. With their adjustable rudder sets, the front seats have good legroom for such a small aircraft. As noted, cockpit visibility is nothing short of fabulous—the best of any GA airplane, other than the Katana/Eclipse/Evolution series.

Of all the GA airplanes we've flown and tested, the Star ranks at the top as being the most fun to fly. It's not quite as well balanced as a Bonanza, but it has no bad habits, and pitch and roll forces are light and easy to manage with the stick. Slow flight and stalls are non-events and even deep into the stall, the airplane simply mushes and could probably touch down that way in a survivable impact. Flaps have little or no effect on trim condition, but neither are they as effective as the barn doors on a Cessna 172.

Landing a Star isn't particularly difficult, but the sight picture over the nose requires some acclimation to avoid too-high flares. Flown into the flare faster than about 65 knots, the Star will float; slower is better.

MAINTENANCE

Typically, airplanes new to the market evidence characteristic maintenance weaknesses at some point. But the Star has done well in this regard. The Lycoming IO-360 is one of the most reliable four-cylinder powerplants available; we heard no complaints from owners about it. One owner complained of teething problems with the Garmin G1000, and three owners said they had problems with electric fuel pumps. The early Star's weak landing lights are a point of contention. We found only four ADs against the airplane, one requiring replacement of the rear hatch retaining bracket, one requiring inspection of the nosegear pivot axle, one requiring inspection of the universal joint on the fuel switch and the last requiring a one-time fuel system inspection.

OWNER FEEDBACK

We have a five-member group that owns a 2004 DA40 at Portsmouth, New Hampshire. We absolutely love

the airplane. It is docile and very easy to fly. It can cruise at 145 knots on 9 gph. It has amazing visibility.

As for reliability, we have had virtually no problems with it. Sure, a the few minor things, but absolutely no major problems of any kind. We've replaced the fuel pump, several sets of tires and a battery. That's it. It continues to purr like a kitten after eight years.

Our annuals are generally around $2000, although we have had them run as high as $5000 when we had some time-mandated inspections and added some equipment such as the Power Flow exhaust.

We figure $16 an hour for engine overhaul, monthly software update of $400 or so and hangar at $500. Overall, we generally estimate our expenses at $16,000 a year for insurance ($3900), hangar, annual, software and unscheduled maintenance.

I owned the plane by myself for about five years and then added partners. There are now six of us who fly it. Group ownership has worked well for us with acceptable fixed expenses and the ability to chip in and buy two Zulu headsets as well as a Stratus weather unit for using on our iPads.

Jim Siverts
Portsmouth, New Hampshire

I have owned three different DA40s since 2005 and have over 800 hours in them. The one I have now is a 2008 DA40 XLS. I have flown it from my home base in Florida on trips as far away as California and New England.

As Diamond's advertising states, my airplane will cruise at 150 knots on 10 gal/hr, but I usually flight plan for 146 knots. Top speed under ideal conditions is about 158 knots.

I can fill all four seats with my family and still take some luggage—although my family of skinny runner types all weigh less than 140 pounds each.

My DA40 has SVT, Power Flow exhaust and the two-blade Hartzell composite propeller. Through a 337 approval, I changed the wingtip lights to slick-looking, teardrop LEDs. I strongly recommend the two-blade Hartzell composite prop over the three-blade composite MT prop or the metal Hartzell. This prop and the Power Flow exhaust added 6-7 knots to my cruise speeds for a given fuel flow or, conversely, a half gal/hr more fuel efficiency at the same speeds.

My insurance quotes for $1 million smooth coverage on a $285K hull ranged from $1732 to $2294.

Dan Montgomery
Inverness, Florida

The DA40 is very easy to fly, great in crosswinds and economical. There were days that other aircraft were struggling with a strong crosswind, and the DA40 handled it without any difficulty.

The front seats were a little tight for me, but not uncomfortably so, and I'm 6 feet 5 inches tall.

I owned an early model with a Garmin 430/530 combination. My only complaint was with the autopilot, which would disengage in even light turbulence and no one could seem to figure out why.

Dave Durden
Des Moines, Iowa

Overall, the DA40 has a sleek, modern look that never fails to attract attention from ramp workers and fellow pilots. The coolest thing about flying the DA40 is that there's a stick, just like a P-51. The DA40 cockpit has a functional layout with the backup steam gauges placed in a neat row at the top and the throttle, fuel, mixture and cabin air controls in the center console, all within easy reach. I have flown a G1000-equipped Cessna 182, and the dash-mounted yoke really gets in the way of the soft-key buttons on the PFD. This is not the case in the DA40.

We have the Bendix/King KAP140 two-axis autopilot installed in our DA40. Having an autopilot helps to hold altitude and maintain heading during high-workload situations and on long cross-country flights, but the DA40 is already stable and when trimmed properly, it doesn't require much control input.

Initially, our KAP140 had a disturbing tendency to porpoise during autopilot-controlled descents. The fix was to install a secondary static pressure port, which Diamond paid for. (Did I mention that Diamond's customer support is outstanding?) After the port was installed, the KAP140 controlled climbs and descents with unwavering accuracy.

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In-flight handling and visibility are consistently praised by owners of the DA40 series.

The leather-covered seats recline slightly and are comfortable to sit in for long cross-country flights. They are fixed to the frame of the aircraft and certified to 26 G for crash protection. The downside of the DA40 cockpit is that it's a little on the small side.

The rear seats are even more comfortable than the front seats, with integrated foot holes for the longer-legged occupants. The large side door for rear access is a class standout in a world of four-place GA aircraft where you have to squeeze through, climb across and crouch down into your seat. The large door opens wide and the rear seats also fold down flat, leaving a long (seven-plus feet) cargo bay for golf clubs, skis and other bulky luggage.

Scanning the skies for traffic and checking the pattern before takeoff is easily accomplished, thanks to the low wing and wraparound canopy. The downside is that it gets warm on the ramp and at low altitudes during the summer. When the temperature hits 90 degrees, you tend to taxi with the canopy open and climb for cooler air as soon as you can. Fortunately, the DA40 has a two-position canopy latch, so you can crack the canopy during engine run-up and on landing rollout to restore airflow to the stifling cockpit.

The large air vents pump a lot of air into the cabin when fully opened, but what the DA40 really needs is air conditioning. I can't imagine what it would be like to fly a DA40 in Florida in the summer. For cold weather ops, the cabin heat works well and the door seals keep out stray drafts. The defrost vents work okay, but it can take a while (10 to 15 minutes) to clear the windscreen of all traces of breath-induced frost.

Flying the DA40XL is effortless and quite a lot of fun. With 40 gallons of 100LL and three big people on board, the aircraft comes off the ground quickly and readily climbs at 700 FPM on a 95-degree day. The large rudder gives plenty of help on tough cross-wind landings, providing a 20-knot demonstrated component.

The large rudder also provides effective ground maneuvering without the need for much differential braking on gently curved taxiways. Due to its motor glider heritage and long wings, the DA40 can be challenging to land simply because it wants to fly. Landings are easy enough, but careful attention must be paid to airspeeds on base and final, or you'll end up floating halfway down the runway. If you try to land the DA40 with an aggressive flare, you may end up with a tail strike on your hands. However, Diamond has thoughtfully provided an aluminum skid plate to prevent any real damage to the expensive airframe.

The biggest drawback to the DA40 is the weak 35-watt halogen bulbs that are a poor excuse for landing lights. Night flying out of rural airports can be challenging and downright scary sometimes, since the dim lights don't provide much advance warning of nocturnal wildlife hanging out on the runway. They also don't provide enough light to effectively navigate strange taxiways at night—a real drawback. One of the frustrating things about this deficiency is Diamond offers a HID lighting option on the DA40XL, but has not provided DA40-180 owners a retrofit kit or service bulletin to take advantage of the increased safety that better lights would provide.

We have had two defective fuel pumps in our DA40. The pumps would simply not turn on when the switch was activated, requiring us to get out of the aircraft, crawl under the belly and tap on the pump to get it going. To Diamond's credit, they replaced both pumps at no charge, which is great service, especially when you consider that they aren't really Diamond's problem. Good job, Diamond!

Overall, the DA40 is an efficient and capable aircraft. With the 100-pound gross weight increase, the useful load of the DA40-180 is just over 900 pounds. That means with the extended-range 50-gallon tanks, you can fly with three adults for four hours at a fuel burn of 9 GPH. The DA40 is not a speed demon, but is reasonably fast at 135 to 150 knots true. The DA40 is a great cross-country machine and is a true pleasure to fly.

Daniel Wiley
Coshocton, Ohio

I purchased my Diamond 2004 DA40 after having flown many Cessna, Piper and Beech aircraft—this is one of the safest airplanes on the market today. The accident rate on this airplane is either the lowest, or among the lowest of any. Some pilots might claim that this is due to the airplane being used extensively in training and so not exposed to the difficulties of cross-country trips. Yet I, and many other owners I know, use the DA40 principally in this latter role. I fly in the Southeast and use it regularly in IMC, where it performs admirably.

Aviation Consumer previously reported the DA40 is one of the nicest handling airplanes on the market. I concur. It is easy to fly, light on the controls and completely enjoyable to land. Visibility is second to none. Trimming the airplane is simple; it has both electric and manual trim. I flight plan for 145 knots and typically see between 140 and 150 (older models are 10 knots slower).

Because the cruise is slightly higher than some of the spam-can airplanes, the DA40 at full cruise bounces around in turbulence more than other airplanes. It is not due to low wing loading, since it has about the same wing

loading as the 182. I find that if I just slow down by 10 knots, the effect of the turbulence drops substantially.

The G1000 is awesome for IFR. Once you go glass, you never go back. One wonders how many accidents have occurred because a pilot loses control in IMC while looking at a three-inch attitude indicator, or because the vacuum pump failed.

There are two downsides to the DA40 for serious IFR. The first is that it has only one alternator. It has the main battery as a backup (about 45 minutes) and a smaller, secondary battery that runs the backup instruments for another 30 minutes. Of course, the alerting system on the G1000 will tell you instantly if you are losing your alternator, so that helps. The second issue is that airplane isn't deiced and never will be. For that, you'll need to move up to the Twin Star or the new DA50 Super Star.

During the first 200 hours on my G1000, I had some teething problems. I had the PFD screen delaminate and I experienced some infant mortality on some of the electronic boxes. Garmin's responsiveness, however, was absolutely stellar and continues to be even with the airplane out of warranty.

Diamond's build quality is superb. I've had zero problems with the airframe, with the exception of a small crack in one of the main gear wheel pants. I think this reflects some of the attention to detail that the Austrian designers put into this aircraft. They put some 16,000 cycles on the DA40 prototypes during testing, one of the most extensively tested GA aircraft brought to market. They paid extensive attention to safety as well, with a double spar in the wing, and aluminum fuel tanks (less likely to leak post-crash).

I had flown an older model of the DA40 previously, but did not like its small baggage compartment. Diamond designed an extended baggage compartment that is far better than what is available in most other aircraft. With the back seats folded down, I can fit my mountain bike in the rear space with room to spare for other luggage. The payload of my aircraft is 540 pounds with full fuel so, like most four-seaters, the DA40 is really a three-person airplane with full fuel.

Unlike the Cessna 182, however, it's hard to offload much fuel for a tradeoff in payload and still maintain reasonable range. I usually fly with fewer than three people on board so for me, it is not an issue. Improving on this, Diamond came out with a 100-pound gross weight increase requiring little more than a paperwork change and is available on all their new DA40s. This is retrofittable to existing DA40s with the "speed gear" (model year 2004 and later). Non-speed-gear DA40s must upgrade to the speed gear to utilize the GW increase.

While the interior is hot in the summer, I can't say it is any worse than most other small airplanes. The DA40's Lycoming IO-360-M1A itself is bulletproof. I've had zero problems with it in three-plus years. There were, however, quite a few instances of cracked exhaust risers in the fleet until Diamond came out with a mod to the muffler mount. That mod fixed the problem. There also were problems with a wire running to the alternator being too short, causing the wire to break. Diamond fixed this with a longer lead.

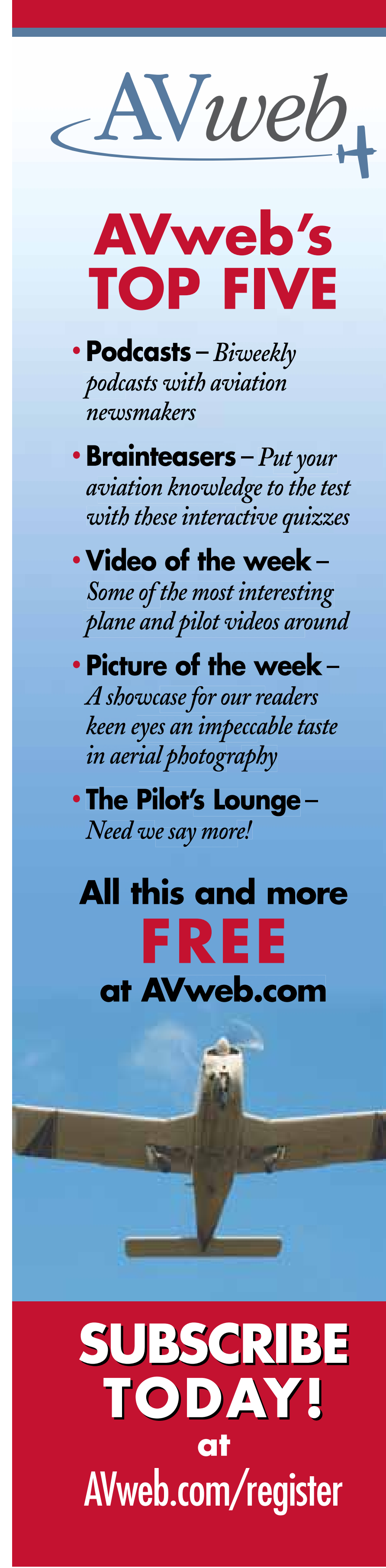
Even though fuel costs were fairly low in the spring of 2004, I suspected that they would rise at some point during my ownership of this airplane. In addition to the G1000 and the DA40 safety record, this is one of the principal reasons I bought the DA40 over a higher performance six-cylinder aircraft. In the three years I owned the airplane, it has flown 710 hours.

The total cost of operation during that time was $111,700. The major components of that included loan interest cost: $36,300; fuel cost: $22,700; maintenance: $17,300 (parts and labor); $12,100 for scheduled maintenance; $5200 for unscheduled maintenance, mostly post-warranty avionics and updates; insurance: $10,000; subscriptions: $3300 (XM, Jepp); hangar rent: $7400 and taxes: $9000. The remainder is miscellaneous expenses.

This translates into an approximate full-up hourly cost of $157. It includes all expenses related to flying, both those directly associated with the airplane as well as any peripheral costs, but doesn't include engine reserves. These numbers also don't include the principal paid against the loan, $46,800 (a cash outlay, but not a cost).

Yet for all of the numbers above, the DA40 is still one of the most economical certificated airplanes available today, especially so when I factor in capability.

Michael Rigg
Via e-mail



Spark Plugs

(continued from page 14)

and gapped every 100 hours and sometimes more frequently, because of their susceptibility to fouling. That 45-minutes of shop time adds up.

That's not the case for fine wire plugs. Not only do they not foul as readily, the iridium wire holds a steadier gap than massives, which cuts the frequency and cost of maintenance.

From our investigation, there is reason to believe fine wires may run hotter than comparable massives. Hotter plugs more effectively resist fouling, a plus in cooler running engines, which often describes normally aspirated engines with good baffling systems.

HANDLE WITH CARE

There is a caution: Iridium is brittle and being too enthusiastic when gapping a fine wire plug can result in a broken electrode and worthless spark plug.

Overall, we believe that the cost of maintenance over the 1500-hour expected life of a fine wire plug in a normally aspirated engine falls on the side of the fine wires, especially for the owner who is pulling plugs for maintenance "on condition" rather than every 100 hours.

Our observations are that massive plugs effectively resist fouling in the hotter-running turbocharged engines being run lean of peak by pilots who also aggressively lean on the ground. Under those conditions, we do not see a benefit to going to the more expensive plug.

Some owners install fine wire plugs in the bottom of the cylinders and massives in the top because they have had fouling problems with massives in the lower holes. That's fine, there's no problem or penalty involved with mixing fine wire and massive plugs in an engine.

PERFORMANCE

We've found almost no data on engine performance and fuel efficiency on fine wire versus massive spark plugs. What we have been able to find is a test that was run by RAM Aircraft several years ago.

In its tests in the same aircraft, running at the same high power settings and 100 degrees rich of peak EGT, RAM reported a 2.2 percent increase in fuel efficiency with fine wire plugs in turbocharged Continental engines. Brake specific fuel consumption for fine wires was 0.498 gal/HP-hour compared with 0.509 for massive electrode plugs.

That may be within the margin of experimental error, nevertheless, a one to two percent savings in fuel over more than 1000 hours adds up.

We have some concern with the RAM tests as 100 degrees ROP at high power settings may well be reduce detonation margins and high CHTs will result in reduced engine life. We are curious as to whether the data would hold up when the engines are being run outside of the "red box" for detonation risk, both rich and lean of peak EGT, and on normally aspirated engines.

Without more data, we can't make a recommendation for fine wire or massive electrode spark plugs when it comes to fuel efficiency.

Our view? If you have a normally aspirated engine that runs cool, are planning to keep your airplane a long time and fly it 100 hours a year, fine wire plugs are worth the investment from a longevity and cost of maintenance standpoint.

Otherwise, the lower cost massive electrode spark plugs will work well. While we won't add a performance or fuel savings affirmation for fine wires without more data, it's nevertheless true that a plug that isn't fouled puts out a better spark, which means better combustion in the cylinder and better performance.

PIPER TRI-PACER

For the February 2013 issue of *Aviation Consumer*, our Used Aircraft Guide will be on the Piper Tri-Pacer, a tube-and-fabric machine that helped usher in the nosewheel era. We want to know what it's like to own these planes, how much they cost to operate, maintain and insure and what they're like to fly. If you'd like your airplane to appear in the magazine, send us any photographs you'd care to share. We accept digital photos e-mailed to the address below. We welcome information on mods, support organizations or any other pertinent comments. Please send correspondence on the Tri-Pacer by December 1, 2012, to:

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