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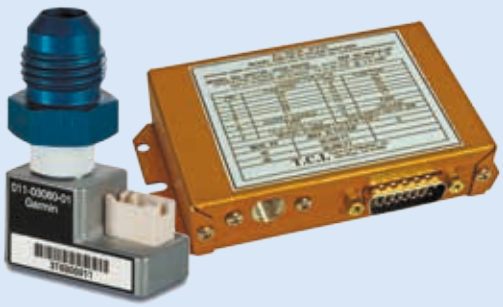

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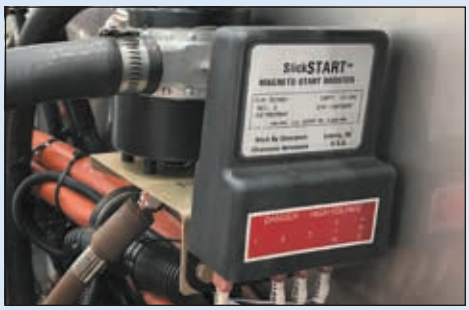

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The Aviation Consumer

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HONDA AIRCRAFT: NEW DIVISION, OLD CULTURE

The Gold Wing in the main photo was shot at Honda Aircraft Company's massive headquarters in Greensboro, North Carolina. It's the first thing you see when entering the main lobby, and presumably it's there as an important reminder of Honda's heritage. In 1946, Soichiro Honda established the Honda Technical Research Institute to develop machine tools and engines. In 2017, the brand name is delivering an ultramodern jet. For motorheads and curious consumers alike, the Honda timeline of milestones is an interesting read.

While studying in the late 1980s, a required reading in my business lecture was Robert L. Shook's *Honda: An American Success Story.* Despite some foggy school daze, the story of Honda's success in America was so intriguing that I embarked on my own academic research focusing on the Honda brand loyalty, which was gaining momentum at the time. I'm among the loyal, having invested plenty in Honda products. My stable currently houses no fewer than five of them, including two vehicles (one from the Acura division), a motorcycle and several pieces of Honda power equipment. Reliability and performance keeps me coming back and I'm not easy to please.

A Honda Aircraft marketing exec said customers like me (but ones with $5 million to spend) are drawn to the HA-420 jet simply because it's a Honda. The company has notoriously ridden the sails of brand loyalty partly because of brand recognition and quality, but I'd call this the ultimate test. Judging by the investment in the 80-acre operation at Greensboro Piedmont Triad Airport, Honda isn't just testing the market and it's easy to speculate what other products could be in the works. Piston models? UAVs? There's more than the jet, in my estimation.

The visit to the spotlessly clean and highly structured aircraft division reinforced a lot of what I learned a long time ago about Honda's corporate obsessions and customs. While the white coat and green cap Honda corporate way of life is clearly on at Honda Aircraft, building and selling the HondaJet isn't like moving generators and Civics. Or maybe it is. For certain, reliability and field support of the HA-420 hangs in the balance just like it did for the automotive line in Honda's early days. Historically in Japanese autobiz culture the buzzword was Kami-sama, or God—which is how the customer was to be treated.

Honda has always enforced a well-organized dealer network, and for a handful of HondaJet dealers in the U.S., initial support of the HA-420 won't be easy. There are now over 40 aircraft in service as we go to press, plus some in the delivery process. There will be a shop learning curve, plus the typical growing pains of a complex first-gen business jet. Flight Safety, which is housed on Honda's campus, is responsible for maintenance and avionics training for the jet and in my experience, the company offers some of the best type training available. Current HondaJet dealerships include TAC Air in Utah, Cutter Aviation in Arizona, Banyon Air Service in Florida, Des Moines Flying Service in Iowa and the in-house dealer at company headquarters. There is more support abroad. Regardless of location, Honda culture expects smiling happy faces from workers and customers.

I think Honda's entrance into the certified aircraft world draws at least some parallels with the automotive market in 1986 when Honda entered the luxury car market with its Acura line. At the time, no other Japanese car maker ever had marketed another vehicle line in the U.S. under a separate division. While the product spoke for itself (the first Acura Legend was a huge success and the automotive press gushed over its fit, finish, quality and performance) there were sizable challenges to overcome. After all, it would be easy for buyers of higher-end BMW and Mercedes cars, to name two, to dismiss the Acura line because it came from a company that also made inexpensive economy cars. But like other Honda products, the Acura was so enticing that it quickly sold itself. How the HA-420 fares against an Embraer or Cessna jet remains to be seen, but Honda's old-school culture and earned respect in other markets can't hurt.—*Larry Anglisano*

OXYGEN CONCENTRATORS

I read the portable oxygen concentrator article in the June 2017 *Aviation Consumer* with interest because my wife has a lung deficiency and has needed O2 when we fly above 6000 feet. We have been using the Aerox system, but she says it dries her nose.

She was prescribed an oxygen concentrator and ended up with the Inogen One G3. She has used it in the airplane at altitudes as high as 9500 feet and reports no dryness. I checked the specs of the Inogen One G3 and the Inogen Aviator G3 for the aviation market and find no difference in specs except for price and claimed altitude usability. I wonder if Windblade has only advertised increased performance in order to appeal to the aviation market. I would expect *Aviation Consumer* to do some independent tests.

Mike White
Kennewick, Washington

During our research, we asked Windblade's Tom Laux about the differences in the Aviator series compared to the Inogen non-aviation concentrators. He told us the company went through a sizable redesign and testing cycle to ensure the Aviator models can operate safely in small aircraft cabins. According to Laux, this meant redesigning the batteries.

Additionally, like the other models, he said the company is currently testing the smaller G4 used in the medical market before it adds a version of it to the Aviator line. This includes altitude testing, testing of the DC converter, examining operating profiles for output levels, plus thermal testing of the spinner indicator. While we're not ones to pay more money for a product simply because of aviation marketing, in this case we're more confident knowing the power supply was reworked and the systems undergo extensive altitude testing.

I think there are some important points to be added to Paul Millner's article about portable O2 concentrator use in aircraft. We have considerable experience with Inogen systems, being the company's largest single customer, renting these units to passengers who travel on commercial aircraft.

Airflow to and from the unit is critical and the picture in the article (where the device is stored between the pilot and copilot seats) could easily result in overheating for the G2 model that's shown. If it was the G3 installed like that it would overheat for sure.

The Inogen POCs must be 41 degrees F to operate. The unit will shut down below that temperature.

As for sharing the system among multiple users, two users on a pulse flow device is risky since it only has so many breaths per minute capacity.

Last, smaller is not necessarily better. If one checks the FDA device complication reporting site, most deaths were either malfunction or insufficient outflow. All non-defective issues are related to smaller pulse flow.

Brent Blue
Oxygen to Go, LLC

AIRBAG SEATBELTS

Thanks for the great article in your June 2017 issue on the efficacy of AmSafe airbag seatbelts. One of the great disappointments I experienced after buying my 1990 F33A Beechcraft Bonanza three years ago was learning that the airbag seatbelts are STC'd only for the A36, not for the V-series or F-series Bonanzas.

I have spoken with AmSafe several times and still don't understand why the company will not pursue an STC for our aircraft. I personally know over a dozen V35 and F33 owners who would retrofit their aircraft in a heartbeat. I even offered to lead a campaign among American Bonanza Society Members, but to no avail. I also asked about the feasibility of getting a group of owners together to pay for a field approval for specific aircraft. The company still said no.

These airbag seatbelts are easily the best safety upgrade we could possibly make to our aircraft and I fervently hope AmSafe will reconsider their decision not to obtain an STC.

Jim Gorman
Birmingham, Michigan

We contacted AmSafe and spoke with Jim Crupi, the company's business development and technical support manager. According to Crupi, one reason why the V-series Bonanzas aren't on the STC list is the bench seating arrangement in earlier models. Still, we didn't have to remind him there are plenty of V models with seating configurations like the A36. But he didn't say a future approval is out of the question. Get enough owners to commit to a non-refundable deposit to start the STC process (as some twin Cessna owners did) and you might get somewhere. It's power in real numbers.

CORRECTION

In the June 2017 First Word commentary about Evolution Aircraft, we incorrectly said the company was in Texas. It's actually in Redmond, Oregon. The company sold the Lancair name and out-of-production model rights to now Lancair International in Uvalde, Texas.

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AIRCRAFT FLIGHT TRIAL

Honda HA-420 Serious Contender

The newest entrant to the competitive world of light jets has made its presence known through performance, efficiency and attention to detail.

by Rick Durden

CHECKLIST

- ✚ At 420 knots max cruise, the HA-420 walks away from its competitors.
- ✚ Pylon-mounted engines mean big cabin and baggage areas.
- ~ It's not a short-field jet—plan on a minimum 5000-foot runway.

An ancient axiom of aviation is that a company that sets out to design a brand-new airframe and wrap it around a brand-new engine design had better have a vast pool of money, expertise and patience or an excellent team of bankruptcy attorneys. The aircraft-manufacturing world is littered with the remains of companies and concepts that simply could not get through the astronomical combination of variables and issues that must be identified and subsequently solved when absolutely everything is new. With the financial backing of an automotive giant, Honda Aircraft pulled it off, although it took nearly 20 years.

Privately wondering whether Honda's engine-over-the-wing concept was a marketing gimmick consistent with the T-tail of the 1970s, we approached reviewing the HondaJet with more than a little skepticism. After all, it is going head-to-head with some very capable jets manufactured by a company that's been building jets for over 60 years (Cessna M2) and one that has the powerful resources of a government behind it (Embraer Phenom 100).

After spending time at Honda Aircraft's massive (more than 600,000 square feet on 130 acres) facility on the Greensboro, North Carolina, airport, submerging ourselves in technical data on the airplane, flying it and getting all of our questions answered in detail, we came away of the opinion that the HondaJet HA-420 is an impressive aircraft. We also think that Honda Aircraft is in the aviation biz for the long run and the HA-420 is just the tip of the iceberg of products that will emerge from Honda Aircraft's secretive facility.

BACKGROUND

Following years of research, the basic design for the HondaJet was sketched out in 1997, a patent for the over-the-wing engine mount configuration was obtained in 2001 and first flight of a prototype took place in 2003. In 2006, Honda announced that it would "commercialize" the HondaJet and said deliveries were expected to begin in 2010.

By 2011 the conforming prototype had demonstrated a 420-knot max cruise speed and rate of climb of 3995 FPM. As the jet approached certification, Honda Aircraft established a network of service centers through the U.S. and Europe. Certification and delivery of the first HondaJet occurred in December 2015 (known icing certification came nine months later). As this is being written, 45 HondaJets have been delivered—15 in the first quarter of 2017—and we were told that the order book stood at 100 for the $4.8 million jet.

Concurrently Honda began developing a small turbofan engine. It then partnered with a company with extensive experience in certifying turbofans, GE Aviation, although GE had never certified one putting out just 2000 pounds of thrust. What eventually became the GE Honda HF120 was certified in 2013 at 2095 pounds of thrust (derated to 2050 for the HF420). The goal of engine

Head on view, top, shows engine pylons mounted on the outboard portion of the engine nacelles. Wingtip, center, has winglet, fence and "bump," spanwise strip in front of aileron for high-speed airflow control. Rail under the belly fuel tank, bottom photo, protects against tank breach in a gear-up landing.

design was lowest fuel burn, lowest weight and highest TBO.

TBO is currently 2500 hours, although it is expected to go to a targeted 5000 hours as operating experience is gained. Weighing less than 400 pounds, it has an impressive 5-to-1 thrust-to-weight ratio, a 2.9 bypass ratio and engine pressure ratio of 24—allowing higher internal temperatures and more efficiency than competitors, helping keep cruise fuel burn to what appears to be the lowest in the HA-420's class while shoving the airframe along some 20 knots faster than its competitors.

THE BASICS

The HondaJet's size is deceptive—at 42.65 feet long, it is almost exactly the same length as its direct competitors, the Cessna M2 and Embraer Phenom 100, yet the cabin is significantly larger (17.8 feet from the forward to aft pressure bulkhead) and it has cavernous aft baggage space (57 cubic feet). The club-seated passengers' feet don't overlap—unheard of in light jets, and apparently a big thing to buyers. The lengthy cabin and baggage area are a result of mounting the engines on the wings rather than on the aft fuselage.

Over-the-wing pylon engine mounts were used on a few jets in the 1970s. The design died out until Michimasa Fujino, designer of the HondaJet, explored the idea of creating a wing pylon that would allow the engines to be positioned well aft. Fine-tuning the pylons—from head on, they look like the arm and hand of a pitcher throwing a fast ball—through extensive wind tunnel testing resulted in a lower drag configuration than fuselage-mounted engines, reduced shock wave strength at higher Mach numbers and generated good stall characteristics—although it still requires a stick pusher.

The small, heavily loaded wing has "bumps" or what look to be small, span-wise stall strips at the midpoint of the upper wing surface in front of the ailerons. We were told they help keep the airflow attached to the ailerons at high Mach numbers. The winglets have small triangle-shaped vortex generators on the upper leading edges for airflow control if a high side-slip is induced.

LOADING

The HA-420 has aluminum wings and a composite fuselage—the composite allowing the complex curves needed to create the drag-reducing, "natural laminar flow" nose. Honda literature shows a basic empty weight (BEW) for the jet of 7203 pounds. The airplane we flew was some 200 pounds heavier, at 7400 pounds. With all of its 2850 pounds of fuel aboard, and a max ramp weight of 10,680 pounds, only 430 pounds of payload remains.

Honda claims an NBAA IFR range with four occupants of 1223 NM. They may have publicized an unrealistically light empty weight that doesn't match airplanes equipped as the customers desire—so the range number may be optimistic for the real world.

Nevertheless, on the other end of the scale—maximizing payload—the zero fuel weight (ZFW) is a whopping 8800 pounds. That makes for a payload of 1400 pounds and 1880 pounds of fuel—two-thirds of capacity—allowing a full-boat realistic NBAA range of 800 NM.

The fuel system turns out to be what we expect in a modern jet—dead simple. Filling is through a single port in the tail. The four tanks are filled progressively—first the two wing tanks, then a belly tank and finally an aft-fuselage bladder tank. The fuel then gravity feeds to the wing tanks, which supply the respective engines via pumps.

While all fuel and lines are outside of the pressure vessel—good crashworthiness design, in our opinion—we look carefully at designs where fuel is carried in the fuselage. We've looked at a lot of post-crash fire data and have observed that there is virtually no increased risk from aft fuselage tanks, so we have no objection

HA-420 TRAINING: FLIGHTSAFETY AT THE FACTORY

Honda Aircraft's HA-420 HondaJet is a turbojet, so despite a gross takeoff weight of less than 12,500 pounds, a type rating is required. We were told that the target demographics—and cross section of actual buyers—split about fifty-fifty between corporate flight departments and owners who were not professional pilots but were going to fly their own jets.

While owner-flown jets have become increasingly common, the challenge of creating a training program that can take a classroom consisting of pro and amateur pilots from zero to the required ATP-level proficiency necessary to pass a type-rating checkride in a reasonable period of time hasn't gotten any easier.

Honda Aircraft selected FlightSafety International to handle flight and maintenance training and specified that FSI set up its training center within Honda Aircraft's Greensboro, North Carolina, facility.

The 14-day flight training curriculum mixes classroom and simulator time and is designed to take a commercial, instrument, multi-engine pilot with no jet time through a type rating. However, in looking at the program, we rapidly concluded that it's not a one size fits all affair—it is tailored as needed to fit the student.

Honda Aircraft also teamed with insurers to set up a program for pilots to fly with newly type-rated owners for a period of time—seasoning, for lack of a better term—to help assure their smooth transition into comfortable, safe operation of their jets.

HondaJet training begins with classroom time. However, the classroom isn't a dry lecture hall. The student is immediately introduced to "operational day flow," ODF, which means they start using desktop simulators that mimic the HondaJet's integrated Garmin G3000 avionics suite in the classroom. FSI's HondaJet Training Center manager Bryan King, top photo, explained that the desktops have touchscreen controllers identical to the control display unit (CDU) of the flight management system in the jet. A mouse is used to move thrust levers and switches. The idea is to move right into flight scenarios, making things as real as possible.

Students next move into one of the graphical flight simulators, GFS, middle photo, with full-scale displays and touchscreens and, importantly, dynamic graphic system schematic displays at the top.

The system displays show what is going on as the pilot works through normal, abnormal and emergency operations of the various systems. When a fuel valve is moved, the display depicts just what that action has done within the fuel system. Students have 24-hour access to the GFS units.

Finally, the students move into the full-motion, Level D simulator, bottom photo. Before doing so, they spend some time with a pilot's seat mounted on a pedestal so that they can clearly see each of the eight adjusting levers and switches so they don't waste precious minutes fumbling to adjust their seat once in the sim. While that may be a small thing, it reflected what we observed to be an almost obsessive attention to detail throughout Honda Aircraft's operations.

We found the Level D sim to be everything Level D sims normally are—a remarkably realistic duplication of flight operations with superb displays. Control response was close to the airplane itself, but as is normal with sims, slightly harder to fly than the real thing.

FlightSafety has been effectively training pilots of all skill and experience levels to fly jets single-pilot in complex environments. With the new operational day flow we think the training has gotten even better.

to the aft bladder in the HA-420. Further, when Cessna put fuel in the belly of the Citation III, it installed a set of fore-to-aft rails under the belly to protect the tank in gear-up landings and crashes. The design worked. We applaud that the HondaJet design includes a robust rail under the belly tank and opine that it will provide

Cockpit, top, showing Garmin 3000 display. Center photo, complex, compound curves provide natural laminar airflow over the nose/cockpit, reducing drag and interior noise. Nose gear scissors, bottom photo, can be disconnected to protect against damage when towing.

adequate protection for that tank.

At the max operating altitude of FL430 the 8-PSI max differential pressurization system generates a cabin altitude of 8000 feet.

Honda worked closely with Garmin to tailor and integrate the G3000 flight deck with the HA-420. We found the touchscreen and shallow menus intuitive. With Honda's close ties with F1 racing, we were not surprised to find buttons and switches on the yoke that made it possible to scroll through and activate many of the G3000 features without letting go of the control wheel.

FLYING IT

The first impression when getting into the cabin of the HondaJet is that it's bigger than expected. Once in the left seat, we were surprised to find that even being 6 feet 4 inches tall, we had plenty of leg and headroom—not a common experience. The seat and rudder pedals both adjust through a long range and should comfortably fit any size pilot.

The HondaJet does not have an APU; however, it does have a "ground cooling mode" in which one engine is operated in a manner that it only burns 90 pounds of fuel per hour while running the air conditioning compressor. The engines are full FADEC, so startup and operation is largely pushing a button or moving a power lever to command the system. Power setting on takeoff consists merely of pushing the power levers to the takeoff detent; on climbout they are pulled back slightly to the max continuous power detent and left until there is a reason to pull them further back.

The major shortcoming we identified with the HA-420 is that it's not a short field machine. Its balanced field takeoff length at sea level on a standard day is 3990 feet. It will land in just over 3000 feet. While Honda says it can use 4000-foot runways, we think that 5000 feet of pavement is the minimum length for a home base to allow for days when the runway is wet or icy.

Where the HondaJet shines is once it gets off the runway—from what we can tell, it outperforms the competition. Its demonstrated climb rate at sea level on a standard day is 3995 FPM. In addition, the extensive system automation turns an engine power loss on takeoff into a non-event. We were prepared to firewall the rudder when Honda chief pilot Tim Frazier pulled one engine back, but the automatic rudder bias made the required input a matter of a few pounds of force.

At FL310 the jet settled down to a cruise at 420 KTAS—some 20 knots faster than its competition. At max operating altitude, FL430, the airplane cruises at 386 knots while burning a total of 600 pounds of fuel per hour, one of the most efficient jets we've come across.

When it was time to descend, deployment of the tail-mounted speedbrakes caused no pitch change, only a slight rumble and substantial increase in the descent rate.

Maneuvering through steep turns, slow flight and around the traffic pattern was delightful. The controls are nicely harmonized with a solid transport feel, but effective enough that the airplane can be tossed around if the need arises. Due to the minimal dihedral and short landing gear, crosswind landings must be made with consideration for the potential of dragging a wingtip. The airplane is limited to no more than 20 knots of crosswind. Above 15 knots it is landed as is a jet with engines in pods beneath the wings: a crabbed approach that is kicked out during the flare. The AFM has specific crosswind landing procedures.

YouTube See a video on the HondaJet at http://tinyurl.com/j95ht2a

CONCLUSION

The quality of the HondaJet and size of its manufacturing facility indicate that the company has the capital to step into the aviation world beyond light jets and make an impact. It has thus far done so with an up and running customer service system and an airplane that outperforms the competition on a lower fuel burn. We think the HondaJet has attracted some buyers because of Honda's reputation for quality in the automotive, motorcycle and small engine world and will continue to do so. We're also quite curious as to what will come out of the massive facility next.

USED LIGHT JETS: CESSNA CJ2+ A STANDOUT

If you're shopping the light jet market and the near $5 million HA-420 HondaJet doesn't fit the budget, there are other choices that might be more palatable. To find out what they are, we talked with several business aircraft sales brokers and the model that came up in every conversation is the Cessna 525A CJ2+. While it may not be an exact apples to apples comparison with the HondaJet, it's arguably the closest competing used jet in the class.

Some mistakenly think Cessna's recently discontinued Mustang jet is similar in performance to the HondaJet, but it is not. It doesn't come close in size or performance. But the CJ2+—the fifth-generation Citation Jet—does. The *Aircraft Bluebook* shows the average retail price for a 2007 CJ2+ at $3.2 million, but sales professionals tell us current market numbers are lower, even for later models with low time. There are many in the field.

The economical CJ2 was perhaps the most popular jet in the Citation line and the CJ2+ (introduced in 2006) built on that success with a slightly larger cabin, at 4.8 feet high and 13.6 feet long. Compare that with the HondaJet's cabin, at 4.8 feet high and 17.8 feet long.

Of course, Honda's over-the-wing engine mounting configuration allows for more cabin width than the CJ2+, which has its Williams FJ44-series engines conventionally mounted to the fuselage. A CJ2+ can typically seat eight total occupants, including the pilot. Like the HondaJet, the CJ2+ can be operated single pilot.

When Cessna designed the original Citation Jet it was able to better the speed of previous straight-wing Citations by going with a natural laminar flow wing thanks to a joint design effort with NASA. The new wing proved to be far more efficient—improving lift-to-drag characteristics by as much as 15 percent compared to older models. Ever hear the term "slotation" used to describe older Citations? The straight wing was partly the culprit for the chiding.

If field length is an issue with the HondaJet, you might have more options with a CJ2+, which has published takeoff numbers around 3400 feet at sea level and 5180 feet at an altitude of 5000 feet at 25 degrees Celsius. Landing distance is around 2600 feet. The CJ2+ has a 45,000-foot service ceiling and a high-speed cruise of around 415 knots true. With four passengers, you'll want to plan on a 1500-NM range. Long-range cruise is around 350 knots true.

Cessna designed the CJ2+ cabin with extra soundproofing and while it's not as quiet as the Honda, ones we've flown in did have reasonably quiet dwellings. It's also a pretty luxurious cabin with plenty of tray tables, 110-volt power receptacles and decent fit and finish. Although in the fit and finish department, we think the HondaJet sets a high standard.

The Williams-Rolls Royce FJ44 turbofan engine has a 3500-hour TBO and a typical overhaul can cost around $350,000 per engine, according to our sources. Each engine delivers 2400 pounds of thrust on takeoff. Average fuel burn, according to an operator we spoke with, is around 140 GPH—considerably more than the HondaJet. If you're hooked on the Garmin G3000 in the HondaJet you might also find it in some CJ2+ models, or you can have one installed.

While the CJ2+ never came off Cessna's assembly line with the G3000, the aftermarket Alpine package replaces the Collins Pro Line 21 avionics suite that was standard..

Cessna switched to the G3000 for the later CJ3 series, and the model line can be downright confusing, in our view. Cessna's M2 is really a CJ1+ modified with the Alpine package, which in addition to the G3000 has upgrades to the pressurization and environmental control systems.

For pilots who are proficient, the G3000 is mainly what makes the HondaJet easier to manage during single-pilot operations and the same can be said for the Alpine-equipped CJ2+. There are 50 percent fewer knobs and buttons, compared to the Pro Line 21. The upgrade strips the airplane down to the point of requiring roughly 10 weeks of downtime and can cost over $900,000.

Even if you don't spring for the G3000 upgrade in a used CJ2+, you might have to do some avionics upgrades. Not all will have mandate-compliant ADS-B or even WAAS LPV approach capability.

Cary Friedman, an experienced jet sales manager who has sold plenty of jets in his lengthy career (most recently with Bell Aviation in Columbia, South Carolina), says that while you'll pay $5 million for a new HondaJet, it does come with a factory warranty and has ADS-B. Still, he advises to look hard at the used Citation market.

"The CJ2+ that's been upgraded to WAAS LPV and ADS-B capability looks like a pretty good alternative to a HondaJet—especially one that has under 1000 hours total time and that's priced around $3.5 million," he said.

As for the used late-model light jet market, Friedman stopped short of calling it flat, but summed it up by saying it slightly favors the buyer. That alone could take some sales from Honda, with a used Citation CJ2+ being a top pick.

—Larry Anglisano

Altitude Encoders: Cheaper If Not Smaller

As ADS-B demand ramps up, so go encoder sales. Price competition is fierce and Trans-Cal has responded with a new model.

by Paul Bertorelli

CHECKLIST

- Trans-Cal and Sandia remain top picks, although ACK has the cheapest encoder.
- If installing Garmin's GTX 335/345 ADS-B transponder, the GAE 12 is a sensible pick.
- Onerous cert rules have kept manufacturers from delivering smaller and cheaper encoders.

Altitude encoders are the doorstops of the avionics world. You have to have one, but don't expect a sweep through the list of available hardware to yield impressive lists of features and capabilities. After all, all the gadgets do is electronically deliver altitude data to a transponder that then reports your altitude to ATC—Mode C.

Although encoders are a backwater market of sorts, the technology has inevitably been impacted by two developments in avionics: the air data computer and the slow-motion breaking wave of ADS-B. Taken together, these two developments have ignited a trend toward either using ADC boxes for transponder altitude information or incorporating the encoding function into the transponder itself. Not many new airplanes have discrete encoders these days.

This is generally good news for avionics buyers because it can eliminate the need for a separate encoder entirely and in legacy airplanes that might require a replacement, the new one can be lighter and perhaps even cheaper if it's combined with an ADS-B installation.

WHAT IT DOES

Altitude encoders were developed partially in response to ATC radar limitations. Primary radar—that is radar that skin paints airplanes and processes the returns—isn't effective at seeing aircraft at great distances from the antenna or small aircraft at any distances. Secondary or beacon radar was developed to address this.

A separate antenna transmits an interrogation signal that your transponder sees and returns. A Mode-A interrogation requests a code—that's the four digits you plug into the transponder—while a Mode-C query asks for altitude. And that's where the encoder comes in. Using a pressure sensor, it converts pressure altitude data to a digital stream the transponder can interpret and pass along electronically to ATC, whose computer applies the local baro setting to accurately compute MSL altitude to the nearest 100 feet.

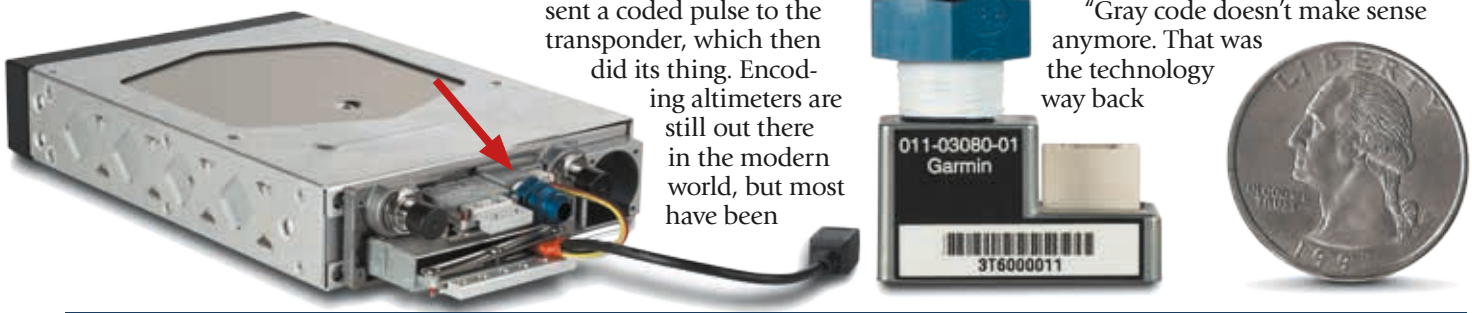
Not so long ago, at least for people who engage in age denial, encoding altimeters were the most common way of doing this. An ordinary looking altimeter sent a coded pulse to the transponder, which then did its thing. Encoding altimeters are still out there in the modern world, but most have been displaced by blind encoders—discrete, boring boxes that live somewhere in the maze of wiring behind your panel.

Blind encoders have proven to be relatively inexpensive and reliable, which is no surprise given how simple they are. Most use a solid-state altitude sensor with a bit of onboard logic to turn the sensor's data into something the transponder can digest. Some museum-piece airplanes may still sport aneroid sensors, but there can't be many left.

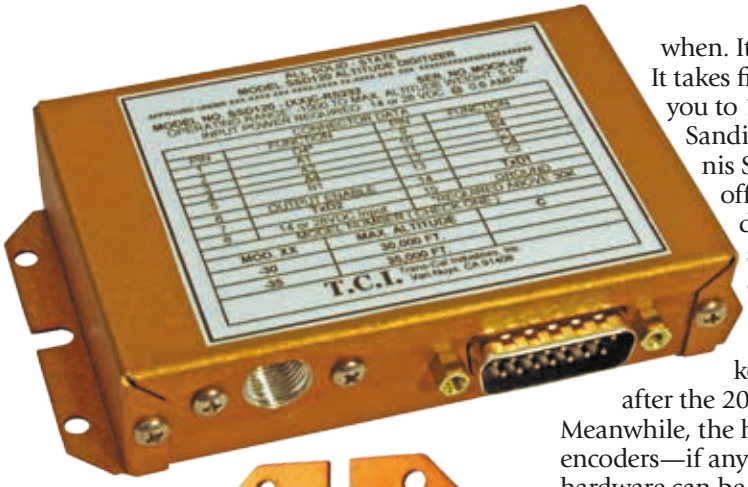
Historically, encoders disgorge something called Gray or Gillham code, a binary numeric code that, while simple, requires a lot of wiring to move from the encoder to the transponder. While Gray-code-only encoders are still on the market, the world is transitioning rapidly to serial data through an RS 232 link. Serial data can be coded to suit the input requirements of any avionics and it requires just a twisted pair of wires, greatly reducing installation complexity and increasing reliability.

Everyone we spoke to in the encoder manufacturing business—and that's not many—agrees that Gray code is on the way out. Not all modern avionics accept it and the profusion of ADS-B boxes on the market all require altitude input data and may not be Gray code friendly.

"Gray code doesn't make sense anymore. That was the technology way back



For its GTX 335/345 ADS-B transponders, below, Garmin split the encoding function. The GAE 12 sensor, right, screws to the rack; the transponder does the encoding. (Quarter sold separately.)



Trans-Cal's newest product is the C or "Charlie" series above. It's meant to be a lower-price option with the same basic capabilities as Trans-Cal's established Nano line, center. Increasingly, the encoder function is being displaced by air data computers like the Sandia SAC 7-35, below. Even legacy aircraft with glass panel upgrades may have ADCs.

when. It's a binary format. It takes five wires just to get you to 10,000 feet," says Sandia Aerospace's Dennis Schmidt. Sandia still offers an encoder with dual Gray code and serial output, but Schmidt says the Gray code demand is a replacement market that will shrivel after the 2020 ADS-B deadline. Meanwhile, the hot development in encoders—if anything in such esoteric hardware can be considered hot—is miniaturization for traditional blind encoders and/or using the altitude sensing capability in air data computers and skipping the encoder entirely. There's also strong price competition in what is already one of the cheapest appliances you can install in your airplane.

CHEAPER, NOT SMALLER

California-based Trans-Cal is the acknowledged traditional leader in altitude encoders and has a well-established record for top-of-the-line equipment. In 2007, after owner John Ferrero took over the company from his father, Trans-Cal miniaturized the company's products in the SSD120 Nano series, which are still offered today. These aren't quite the size of a quarter, but at 2.5 by 3.4 by 1.4 inches, they're not much larger either.

Trans-Cal has the most complete line of encoders, offering eight models, most of which output both Gray code and serial data and include variations on connector type and temperature and operating environments, including a model designed to operate as high as 100,000 feet. The most popular option is probably the SSD120-30N, which retails for about $350. Trans-Cal encoders live inside a solid metal case and have warranties up to 42 months. Trans-Cal's Ferrero says failures of any kind with these encoders are rare, as little as half of one percent. Improbably, even for obscure hardware costing $350, the encoder market has become intensely price competitive, so as we go to press this month, Trans-Cal is introducing a new product called the Charlie series. Ferrero is blunt about the purpose of the new product.

"We live in sort of a Wal-Mart world. People want to buy often and they don't care if it lasts. They just want it cheap," he says. So the new Charlie series encoder is simply built cheaper, with a stamped aluminum case instead of an extruded, machined case and a single 15-pin connector rather than two connectors. And although it contains the same electronics as the Nano line, it's slightly larger.

"This C-unit is designed to be an affordable solution for anybody who's looking for ADS-B compliance, putting in a serial-data-capable unit with 10-foot resolution," Ferrero says. He declined to say what the retail price will be, but said it will be $50 or $60 cheaper than the Nano. We take that to be just under the $300 mark. The product should be available by midsummer 2017.

CHEAPER AND SMALLER

Meanwhile, in its GAE 12, Garmin has pursued encoding technology that's both smaller and cheaper but might best be called a non-encoder. The GAE 12, as shown in the photo on the previous page, is literally the size of a quarter. Its static fitting is as big the device itself. That's because the GAE 12 isn't really an encoder, but a smart pressure sensor.

Garmin's idea was to offer a small, solid-state pressure sensor that outputs

CONTACTS...

ACK Technologies
408-287-8021
www.ackavionics.com

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

Garmin International
800-800-1020
www.garmin.com

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

Trans-Cal Industries
818-787-1221
www.trans-cal.com

data into a serial peripheral bus, the same protocol computer processors use to talk to hardware. That's piped into the transponder itself, which then does the electronic massaging to convert the data into pressure altitude for transmission to ATC.

The $249 GAE 12 screws to the back of the transponder tray and the static line connects directly to it. The advantage is that if the transponder has to be removed for repair or replacement, the GAE 12 stays put and the static system remains undisturbed. That avoids the hassle and expense of recertifying the static system for a minor repair.

The GAE 12 can best be thought of as an offshoot of air data computing; it's simply the altitude-sensing portion of an ADC box. It works only with Garmin's GTX 335/345 ADS-B Out transponders. Those transponders, which have become the go-to products for ADS-B compliance, can also accept Gray code and serial input from other encoders.

The GAE 12 has another trick: It serves as a configuration module for the transponder. At installation, the technician can use a computer to set up the somewhat involved parameters required for ADS-B Out transponders. Once that's done, if the transponder is repaired or replaced, it will be automatically reconfigured when the box is inserted back into the tray. Garmin uses configuration modules for many of its products, some of which are just flash memory chips located in the harnesses. The GAE 12 is just another way of skinning the same cat.

PRODUCT*	TYPICAL RETAIL	OUTPUT	COMMENTS
ACK A-30.5	$227.95	Gray code only.	Basic encoder suitable for legacy installations that require Gray code.
ACK A-30.9	$232.95	Gray and serial in 10-ft resolution to 42,000 ft.	Package includes harness, mounting and static plumbing fittings. Least expensive serial model.
GARMIN GAE 12	$249	SPI direct to transponder only.	Works only with GTX 335/345. Transponder does the encoding. Serves as configuration module.
GARMIN GAE 43	$279	Gray and serial in 10-ft resolution.	Garmin-branded Sandia SAE 5-35. Price recently reduced.
SANDIA SAE 5-35	$450	Gray and serial in 10-ft resolution.	Features inflight monitoring to alert pilot to altitude deviations.
SHADIN 8800-T	$1323	Gray and serial in 10-ft resolution.	Old-school box designed for use with Shadin's altitude management system. Not a player for replacement market.
TRANS-CAL SSD-120 SERIES	$319 to $439	Wide variation in output formats. 10-ft resolution available.	Trans-Cal's line is the most flexible in the industry. These will remain available even as the cheaper C-model arrives.
TRANS-CAL SSD(XX)C	$280**	Gray and serial output in 10-ft resolution.	The C-series is Trans-Cal's new lower-price line. Expected to be available by summer 2017.

** Table represents a top-level survey of altitude encoders. Not all are listed.*
*** Our estimate of price based on Trans-Cal information. Final prices weren't available at press time.*

MARKET TRENDS

The companies we spoke to for this article aren't of a single opinion on whether the onset of ADS-B has upended the encoder market. Trans-Cal's Ferrero believes it has and that the encoder market has become price and volume driven. Once the market leader, Trans-Cal has lost share to other manufacturers and since encoders do basically the same thing, price is the main competition variable. "I want back some of what we lost," Ferrero says.

But even as the market gets more competitive on price, it's not likely to evolve much in basic capability or feature sets, which is another way of saying what you see now is pretty much what you're going to get for the foreseeable future. Both Sandia's Schmidt and ACK Technologies' Mike Akatiff told us that advances in hardware miniaturization make it possible to build encoders that are smaller, cheaper and use less power than current technology. That's essentially what Garmin did in incorporating the encoding capability right on the transponder board.

But for gadgets costing $300 or less, the margins and market aren't there to invest in rethinking the basic discrete altitude encoder. Trans-Cal's Ferrero says the additional testing to certify a new generation of encoders would cost at least $250,000, an investment unlikely to be returned in greater sales or margin.

"We could shrink this thing down to the size of a postage stamp if we really wanted to. But we don't have plans to do that. The TSO certification is so onerous, we just don't want to change it," says ACK's Akatiff.

As ADS-B installations accelerate—and they appear to be doing just that—the manufacturers expect demand for encoders to increase, especially for aircraft that have either older electromechanical encoders or units that output Gray code only. All ADS-B boxes require encoded altitude from some source and may or may not accept both Gray code or serial input. Then there's the question of resolution. Most of the new encoders will output resolution down to 10-foot increments, if not down to 1-foot. Is there any need for this?

"I can't answer that," says Garmin's Bill Stone. ATC's resolution requirement is the same 100 feet it has always been and Stone says the resolution of serializers exceeds the accuracy, so what's the point of 10-foot increments? "I don't think it's entirely necessary, but it's so easy to do. If you have a way to read the data, and most GPSs do, you can read it," says Mike Atakiff.

Bottom line: Altitude resolution shouldn't be a buying factor for a new encoder. As Ferrero observes, it's a price-driven market, so buying solely on price strikes us as a rational decision. We like Garmin's idea of splitting the sensor and the encoding function to preserve static system integrity. On the other hand, new encoders are so reliable that tearing into the static system to fix one between 24-month certifications will likely be the least of an owner's worries.

Editor's Choice Awards: Diamond Wins for Guts

Investing big in more piston singles for the current market may be nuts, but we tip the editorial hat to Diamond for getting bullish with the DA50.

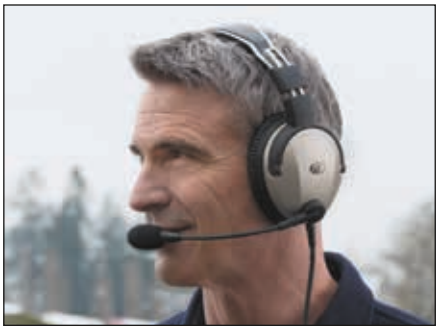
Although piston aircraft sales are mostly in the tank, Diamond Aircraft came to the Aero show in Germany this past spring announcing not one, but three new single-engine piston models to be designated the DA50. It has its competitive sights directly on Cirrus.

To compete against Cirrus' top-selling SR22T, the DA50-VII will be equipped with a FADEC-driven 380-HP Lycoming TEO-540 six-cylinder engine and retractable landing gear. Recognizing lost sales contracts in the training market to Cirrus' SR20, the new fixed-gear DA50-IV will be a four-place model powered by the Safran/SMA SR305-230E four-cylinder diesel. Last, the DA50-V will be a five-seat version (utilizing a wide bench seat behind the two front seats) powered by the 260-HP Safran/SMA SR305 diesel.

Diamond's CEO, Christian Dries, says the company is being aggressive with a 2018 or 2019 certification schedule, plus it has plans to expand the DA50 series for more seating options, plus a turbine engine option. Whether or not these new models can stimulate the declining market—or even take some of the wind out of Cirrus' sails—is anyone's guess, but Diamond's aggressive investment is enough to win *Aviation Consumer's* Editor's Choice Award for company of the year. The following products earn Gear of the Year awards.

BEST MID-PRICED HEADSET: LIGHTSPEED ZULU3

Recognizing that the Zulu2 excelled in the crowded ANR headset market, Lightspeed made the set better with subtle improvements and priced it cheaper than the market-dominating



Bose A20. At $850, the third-generation Zulu3 gets new earcups that contribute to more comfort and better audio performance, Kevlar braided audio cables that are nearly indestructible and a simple, but generous, feature set that doesn't require an engineering degree to figure out. After flying with the Zulu3 we liked it enough to give the product an editor's choice award for value and quality. Visit www.lightspeedaviation.com.

BEST ADS-B DEVICE: L-3 LYNX NGT9000

While there is no shortage of mandate-compliant ADS-B systems, we're sold on all-in-one transponder-based solutions. For one thing, they make for an easier installation, plus they make perfect sense for aircraft that haven't seen a transponder upgrade in a while. L-3's NGT9000 smart transponder advances the interface several steps higher because it incorporates color multifunction display capability on its dual touchscreens.

What impresses us the most is that L-3 continues to advance the feature set. Where other systems won't scan for traffic below 500 feet, L-3 added ATAS aural traffic alerting to the device, which surveys and issues traffic alerts for airborne traffic targets at all altitudes, making it a good utility in the traffic pattern.

The NGT9000 can also display Stormscope lightning data when connected with the WX500 system, plus it has two options for terrain alerting. There is mandate-compliant TAWS-B and the new TerrainVision advisory terrain feature. The device also connects with a variety of tablet apps, including ForeFlight.

The NGT9000 starts at $6170, which isn't exactly a budget-based solution, but we think it packs enough punch to earn an editor's choice award for a second year in a row. Contact www.l-3lynx.com.

BEST ACTION CAMERA: GARMIN VIRB ULTRA 30

Unlike GoPro, Garmin isn't a camera company, but it's been aggressively marketing the VIRB series action

cameras the past few years. Aggressively marketing new models is key—something we think GoPro has lost.

We recently put Garmin's latest VIRB Ultra 30 head-to-head with GoPro's Hero 5 (and the GoPro Session series) where it crushed it in several areas, partly because it has more aviation-focused features like GPS, filters and audio adapter cables. We also like that the VIRB has Garmin's suite of ANT+ sensors, which makes it a worthy player for cycling, snowboarding and other action sports. It's also an improvement over the VIRB XE because it has an onboard touchscreen viewer, more shooting resolution and more frame-rate options. It also mates up to GoPro mounting hardware. In our world, that's a real plus. Visit www.garmin.com.

BEST PORTABLE CO DETECTOR: CO EXPERTS MODEL 2016

For protection against aviation's silent killer, we've always advocated the use of a portable CO detector. In

a recent roundup of these devices, the CO Experts Model 2016 was a standout because of its sensitivity and useful features, including a low-level alarm. With a $199 list price it's the most expensive of the portable models we evaluated, but we think its features outweigh the cost. For example, it displays CO starting at 1 PPM and makes its first alert immediately at 7 PPM. It has a graduated series of alarms as the CO concentration rises—there is no time delay between hitting a concentration level and the alarm sounding. It has a silence feature allowing the user to shut off the alarm temporarily—the length of time the alarm will remain silent decreases at higher CO concentration levels and the alarm will sound again if the CO level increases. Contact www.coexperts.com.

BEST USED AVIONICS SOURCE: BENNETT AVIONICS

Sourcing used avionics can be a crapshoot. Buying from a reputable source is the first step in the confusing process. To our knowledge, East Granby, Connecticut-based Bennett Avionics is the only long-established

avionics company that deals entirely in used avionics and doesn't do installations. It's that narrow focus that enables company founder Harley Bennett—who has been selling used avionics for nearly 50 years—to keep prices low and customer service as good as it gets.

Bennett only sells certified equipment that's backed with a 90-day warranty (or with a one-year warranty for an additional fee) and subcontracts repair and certification to a network of shops around the country. Some of these shops specialize in repairing older equipment—an imperative trait in the used avionics business. Contact the company at www.bennettavionics.com.

BEST COMPACT FLIGHT TOTE: SPORTY'S HP IPAD BAG

We don't need a bulky full-size bag to carry a tablet computer and other small stuff, so we went searching for the best compact flight totes. While we found several space-saving options from MyGoFlight and Flight

Outfitters, we liked the Sporty's HP iPad bag the best.

The iPad bag is part of Sporty's recently introduced Flight Gear HP collection, which also includes the redesigned full-size Captain's model. What's good about the new bags is the weight savings—nearly 30 percent lighter than the old ones, but they are stronger and beefed up with reinforced handles.

The $69.95 iPad Bag, which measures 12 inches wide by 7.5 inches deep and 13 inches high, focuses on organization and storing an iPad, of course. What really sold us was the ability to house a headset without having to stuff it into a compartment. Instead, the bag has a headset hanger that keeps it suspended in the main compartment.

The outside area of the bag has a transceiver compartment, bottle holder, phone pocket and chart pocket, while the inside has a padded tablet pocket with a charging cord pass-thru for connecting a power supply.

Sporty's also offers optional accessory pockets called Gear Mods, which are modulated storage compartments that can be moved form one bag to an another. Contact www.sportys.com.

BEST FLYING GLASSES: FLYING EYES OPTICS

The original Flying Eyes Hawk sunglasses turned out to be the most durable pair of sunglasses we've owned. Plus, with interchangeable thin temples (and also a headstrap) designed to take the ache out of wearing headsets, they were also the most comfortable. Even better is

that they work well inside a full-face motorcycle helmet. We liked them so much, in fact, we invested in prescription transition lenses, which are made by Shamir Optical Industry—a top lens maker.

But as much as we liked the Hawks (the basic frames start at $336 with prescription lenses) and Flying Eyes' exceptional customer service (the company will replace the glasses for $79, plus shipping) we wished for more modern styles.

The company listened and brought the ComfortStyle line to market. Choose between athletic wraps, aviator style and other trendy frames, plus reader frames. Visit www.flyingeyesoptics.com.

BEST LSA FOR TRAVELING: BRISTELL NG5

Given its sophisticated integrated avionics suite with an envelope-protected autopilot, six hours of endurance, 120-knot cruising speed and generous interior and baggage space, we walked away from the Bristell NG5 flight evaluation pleasantly surprised. It's not often that an LSA hits all of those sweet spots, but the NG5 does—on one-quarter the fuel and one-fifth the price of a high-end sophisticated flagship single.

Resembling the Czech Sport Aircraft SportCruiser (which Piper branded as the SportCruiser), the Bristell NG5 has a base price of $126,900, but can easily sell for around $180,000 when equipped with options, including the ground-adjustable three-blade composite prop. The airplane we flew had a 100-HP Rotax 912iS (which can burn as little as 5 GPH), but is also available with a 115-HP Rotax 914 turbocharged engine. Contact www.bristellaircraft.com.

BEST PANEL USB POWER SUPPLY: GUARDIAN AVIONICS IFDR 250

Face it, since smartphones, tablet computers and portable ADS-B devices are forever part of our flying, USB power receptacles have become important accessories. Sure, you could use a USB adapter sourced at the local hardware store and plug it

into the aircraft's cigar lighter—if it has one that works. The problem is some adapters don't have the correct step-down output voltage and you risk frying your devices, plus there is the potential for electromagnetic interference. This can create havoc with injected audio system noise.

We think the Guardian iFDR Power USB ports are a better solution. Available with either a single USB port ($249) or dual ports ($299), the devices come in a couple different versions for mounting them on the panel or into interior components, which is useful for the rear cabin. Better yet, they can accept between 9 and 48 volts DC input voltage and output a stable 5 volts of power from each port—enough to quickly charge a modern smartphone.

Guardian says the installation can be signed off with a logbook entry and unlike other power supplies, you shouldn't need an FAA field approval. The iFDR Power is also available with a chassis that mounts to Guardian's tablet panel dock. Contact www.guardianavionics.com.

BEST BUDGET EFIS: GARMIN G5

Yes, we know the Garmin G5 electronic attitude display doesn't have autopilot interface, but we still think

it betters the competition because of its ease of installation, display quality and backup battery life.

The G5 has a 3.5-inch QVGA color LCD display with a 320- by 240-pixel resolution and while it's a self-contained instrument, it requires a remote GPS antenna and connection with the aircraft's pitot and static system. We like that the G5 is approved (under a sizable AML-STC) as a replacement for the attitude indicator or the turn coordinator, although it can't replace both instruments.

The other thing we like about the G5 is its bezel design, which measures 3.4 inches wide and 3.6 inches high. This means there is plenty of space between it and the other instruments in a typical "T"-configured instrument panel, plus it can be removed and reinstalled from the front of the panel. So, how's the autopilot approval coming along, Garmin? Visit them at www.garmin.com.

BEST BATTERY CHARGER: BATTERYMINDER CEC1-AA

In our view, a battery tender is the best investment you can make to prolong the life of a battery. The $240 BatteryMinder from VDC Electronics was specifically calibrated for aircraft batteries and there are models appropriate for Gill, Concorde and Hawker-Odyssey batteries.

What we like about the latest-generation BatteryMinder is that it has been tweaked for simple, one-touch operation and it uses basic icons on the case to show the current charge status of the battery. Contact www.batteryminders.com for more.

Engine Tough To Start? SlickStart, iStart Help

Champion's SlickStart ignition booster provides a firestorm of supplemental spark, while the iStart supplemental fuel delivery system helps injected engines.

by Jim Cavanagh

CHECKLIST

- The SlickStart and iStart might save you from frying a starter during prolonged cranking.
- SlickStart can help start an engine with partially fouled spark plugs.
- These devices aren't a cure-all for problems in the ignition and fuel delivery system.

Cold starts, hot starts and over-enthusiastic priming are just some of the scenarios that can lead to an airplane sitting on the ground because the engine refuses to fire.

The best way to ensure a quick engine start is to boost the energy to the spark plugs because with enough spark, the fuel and air mixture will certainly burn. Champion Aerospace's SlickStart magneto booster promises to do just that. Here's how it works, plus an overview of aircraft piston engine ignition theory.

DISSECTING IGNITION

Before looking at the ignition booster concept, a review of the ignition process is in order. Because the typical piston aircraft engines are designed to turn slowly, designers had to develop a way to get the cylinders firing. This can be a real trick because a slow-turning crankshaft is not conducive to starting due to the relative effect of the spark duration. Using magnetos (which are not dependent upon the electrical system to create a spark for firing the plugs), engineers needed a way to increase the initial voltage to the spark plug.

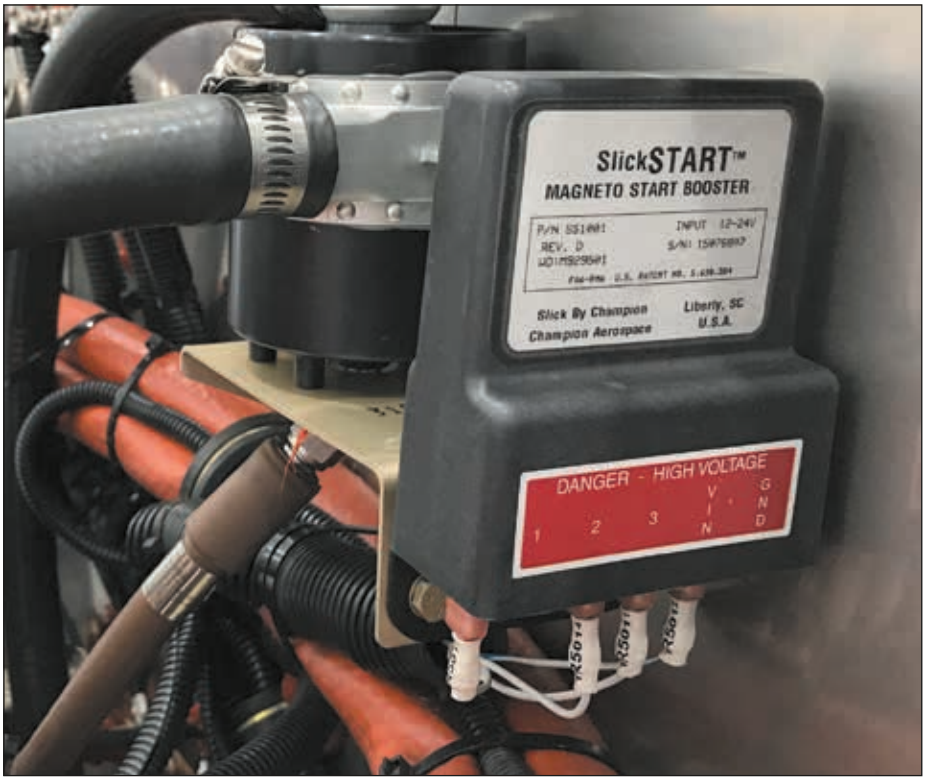
A magneto will create a spark if there is enough rotation. The magnets move around a coil (the basis for electricity), but normal turning sometimes doesn't produce enough spark. Back in aviation's infancy, inertial starters and shotgun shell-like cartridges were the best way to start an engine. Eventually, impulse coupling made things a lot easier.

An impulse coupler is a spring-loaded mechanism that is usually installed on the left magneto and does two things. It delays the firing of the magneto to more of a top dead center position and when the catch lets go, the built-up energy in the spring speeds up the rotation of the magneto. Both create a much hotter spark that fires at a more optimal time in the combustion process. This is controlled at the key starter or the mag switch, opening or closing the P-lead circuit as necessary—left mag on, right mag off—to avoid the possibility of a backfire or engine kickback.

Kickback is when the piston is not quite up to the top dead center of the crank's rotation and a premature firing of the fuel/air mixture will drive the piston backward, potentially causing many bad things to happen. When the engine begins to run, the impulse is disconnected. You can tell which mag has the impulse because of a spacer between the mag body and the harness cap. Consider that hand propping an engine could only be possible with impulse coupling.

SHOWER OF SPARKS

The shower of sparks, or SOS method for starting, was originally used



The SlickStart module generally mounts on the firewall and connects with impulse-coupled magnetos.

The self-contained SlickStart SS1001, top, works with Slick mags, middle, but versions are available for some Bendix mags. Cirrus is delivering the SlickStart on its SR22 and new Lycoming-powered SR20, bottom. It's standard equipment on a variety of other aircraft.

on the Ford Model T and later on some aircraft engines. Shower of spark systems consist of two magnetos, but the left mag has two sets of points—one in the normal advance position, and the other in a retarded position. A vibrator switch (think of an old doorbell buzzer that creates a rapid firing sequence of sparks to the coil) is usually mounted on the firewall, taking the advance points out of the loop, while activating the retarded points. Rather than one spark from an impulse coupling, there are nine to 12 sparks per sequence, providing much more opportunity for the spark to fire. These systems were on a number of Beechcraft and earlier Mooney models and are still in service.

The problem with these systems is that the technology available back then only allowed the vibrator to increase the voltage per spark a moderate amount. While an engine will run well on less than a 10 kV spark from a magneto, impulse coupling increases this voltage by 4.8 kV, but there's still only one spark at the retarded position. Shower of spark systems create a much longer spark sequence.

CHAMPION SLICKSTART

The SlickStart was actually developed in 1997 by Unison Industries and is now owned by Champion Aerospace. Champion's Joe Logie reinforced the variety of factors that can cause an engine to be difficult to start. Improper priming (either too much or too little fuel), frosted spark plugs, fouled spark plugs and sometimes simply the nature of the engine can make starting a chore.

Now that you understand how the shower of sparks works, think of the SlickStart device as a more modern, computerized approach to the SOS concept. By creating a long, powerful voltage for low-speed starting, SlickStart increases the length of the starter sequence while also increasing the electrical energy that gets to the spark plug by up to 340 times that of an impulse-coupled spark.

Moreover, there is inherent drag in any engine—the larger and more powerful often being the most difficult to start. This drag presents inertia that needs to be overcome in order to get things turning. Cold temps, fuel problems and cold oil are all common problems. But if there is fuel and air, then all that is needed is heat, or in this case a spark, to create fire. Getting enough of a highly charged spark to the spark plug is the trick. That's where the SlickStart system comes in.

The SlickStart is a single module that attaches to the aircraft firewall, measuring roughly 5 inches tall and 3.5 inches wide. The device generates a shower of sparks electronically by using a capacitive discharge to store energy and shoot it to the magneto when the starter is engaged. Champion calls it a firestorm of electricity and indeed it is, as the intensity of the spark is measured in kilojoules.

COMPATIBILITY, INSTALL

The SlickStart is designed to replace the older Bendix/TCM vibrators when used with Champion's Slick mags. It draws 5 amps of current and operates on both 12- and 24-volt electrical systems. If ordering the system on your own, be sure to check compatibility. The system comes in different versions, depending on the magnetos.

The SlickStart model SS1001 is compatible with 4200/6200 and 4300/6300 series Slick magnetos. Worth mentioning is for best performance, Champion suggested converting to one retard breaker on the left mag for 4345, 4347 and 6393 mags.

Other options include hooking it up to single and dual impulse coupled mags and single or dual retard breaker mags. For twins, one SlickStart module is required for each engine.

The SS1002 unit is compatible with Bendix 20/200 series mags, but is not compatible with the Bendix 3000-series dual mags.

If you have an electronic tachometer, its lead needs to be moved to the right magneto, if compatible. One

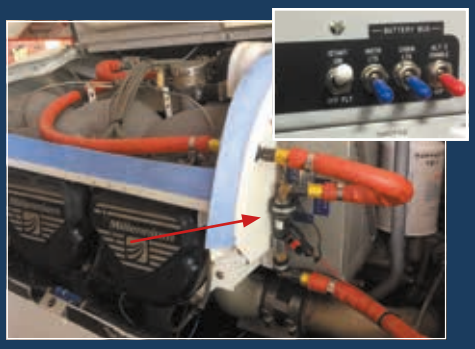
iSTART: COMPUTER ASSISTED HOT STARTS

Fly an aircraft with a fuel-injected engine and chances are you'll eventually deal with stubborn hot starts, with battery voltage and starter life hanging in the balance. Texas-based iStart has a solution with its secondary fuel injection control system, a digitally controlled priming assist system that is designed to take the guesswork out of hot-start engine priming by computerizing the start sequence.

In a nutshell, the self-contained digitally controlled iStart has a secondary fuel injection source that's piggybacked to the engine's normal fuel delivery system. The iStart computer samples the engine temperature, starts the fuel boost pump and injects the precise amount of fuel for engine priming, cranking and idling.

The iStart doesn't replace the existing fuel distribution system and the plumbing is independent of the engine's main fuel injection metering unit. Its dedicated fuel delivery lines connect to the existing fuel injector spider (distributor) after passing through a computer-controlled secondary injector, allowing fuel from both the primary and iStart system to reach the cylinders. It's considered a failsafe system because it is only used for starting and it can't operate when the engine is running. The computer is also connected to one of the engine's magnetos, shutting down if it senses 100 RPM or higher. When using the iStart, the throttle is cracked, the mixture control is always in idle cutoff and the system has to be energized with a panel-mounted master switch. No, you can't use the system for emergency engine starts in flight.

When the system is on (verified



with a flashing status annunciator on the instrument panel), the iStart computer is constantly monitoring engine temperature and RPM while the engine is cranking and firing and adjusts the fuel delivery throughout the start sequence. Once the engine is running, you advance the mixture control from the idle cutoff position and set the throttle for 1000 RPM. After 10 seconds and when the engine RPM stabilizes, the status annunciator flashes and the iStart system automatically shuts down.

Once running, the engine is being fed by the engine's primary fuel delivery system and the iStart is completely disabled.

Installation can generally be accomplished on typical Lycoming and Continental engines in one shop day. The iStart fuel injector assembly is mounted on top of the engine adjacent to the engine's primary fuel injector distributor spider. A T-fitting is inserted into the fuel line that connects the fuel injector metering unit to the fuel injector spider. The system has to be connected with a pullable circuit breaker.

The iStart sells for $995 and doesn't include fuel line or fittings because not all installations are identical, as far as component mounting locations are concerned.

The iStart system has been proven on a variety of experimental aircraft over the past six years and the company has recently earned STC approval for the single-engine Beechcraft line (normally aspirated models) and also for the Bellanca Viking series. Company founder Damon Berry (who once managed Plane Power and now partners SureFly) said STC approval for Cessna singles is expected in the immediate future, with Piper, Diamond and other aircraft approvals to follow shortly thereafter. Contact www.istartair.com, 817-219-0007.

—Larry Anglisano

wire from the device connects with the starter solenoid so that it is only engaged when the starter is working. There are also ground and P-lead connections to the left mag, and a connection if there is a retard breaker magneto.

In our research, we found that a competent tech might install a single system in a half day. The unit doesn't come with all hardware required for installation, including mounting bolts and other pieces.

CONTACT...

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864-843-1162
www.championaerospace.com

iStart Partners
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www.istartair.com

WHAT'S IT WORTH?

We've all felt the reassurance when an engine starts quickly and smoothly, and many of us have also lost the battle by flattening batteries and toasting starters when trying to light finicky engines.

Assuming the engine is in good health, including magnetos, plugs and the ignition system as a whole, we think the Champion SlickStart can contribute to quicker starts, based on the Lycoming and Continental engines we've operated with it installed. Others are pleased.

Real-world feedback collected during our research was favorable and we think the $829 street price is fair, plus installation is straightforward.

Its design theory is easy to support. Regardless of the reason it won't start, your engine is much more likely to get online if you can pour massive amounts of spark to the plug, which is what the SlickStart does.

Of course, we still wait for a modern electronic ignition system and while Champion supports the Lasar ignition, we've heard rumors of a replacement product in the works. There's also Electroair, and SureFly is close to earning an STC for its SIM electronic ignition. We'll watch this market and report on it in future issues of *Aviation Consumer.*

YouTube See a video on the iStart system at http://tinyurl.com/j95ht2a

Avionics Corrosion: Moisture Is The Enemy

Temperature differentials, improper storage and ram air cooling can corrode expensive avionics. Routine inspection and periodic antenna replacement is worth the effort.

Staff report

There's a lot of emphasis on airframe corrosion, yet owners and technicians rarely consider the corrosion that plagues avionics—a system that can be more susceptible than the airframe. Big-airplane maintenance programs keep on top of it for good reasons.

Corrosion can build on components that you might not give a second thought. This includes contact pins on radio connectors, antenna RF connectors (and the hidden skin at the base of the antenna—a real disaster in the making) and components that reside under the floor, inside the wing root and inside of radios.

In this article, we'll take a look at problem areas and what you and your shop might do to stop avionics corrosion before it begins. That might include some upgrades to the avionics cooling system and antennas.

CORROSION 101

There is more than one face to corrosion and many types can grow on avionics equipment, depending on the environment, the material and the location within the airframe. It's worth reviewing a few common types.

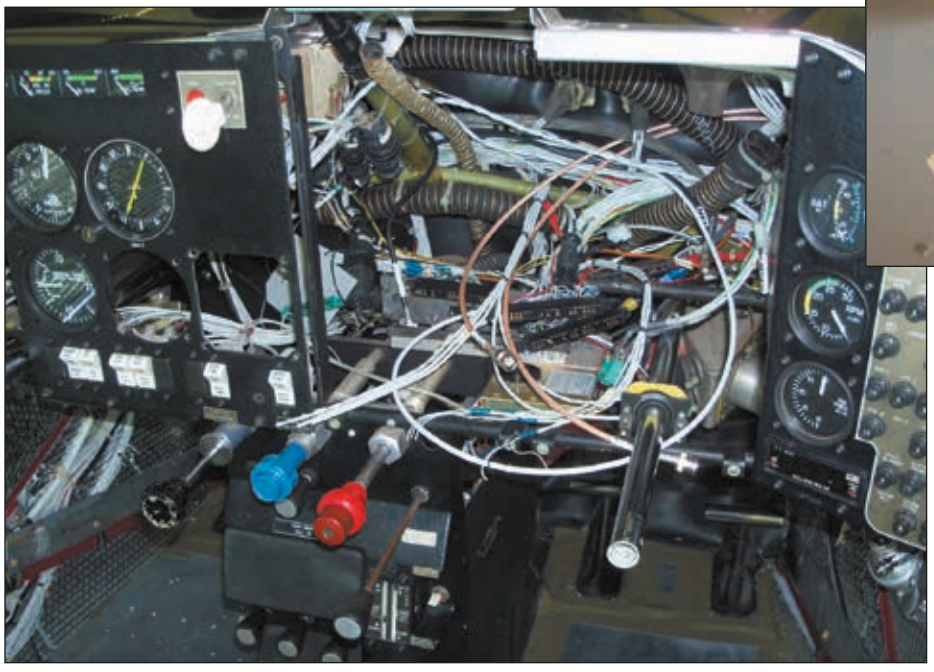
The most common is surface corrosion and it results from a direct chemical attack on a metal surface. We're talking about surfaces like mounting trays, connector backplates and the radio chassis to name a few. It's often referred to as uniform surface corrosion and it can be difficult to spot in its early stages.

The chemical elements that make up an alloyed metal are different and thereby become anodes and cathodes. The anodes and cathodes are quite small and constantly shift from one area of the surface to another. There are telltale signs.

A dull or etched surface is usually the first indication of uniform surface corrosion. Continued attack is followed by roughness and a frosty or powdered surface. You've seen this before, although you might have to dig (teardown is the official word in shop talk) to find it on some avionics components.

Pitting corrosion is a severe form of concentrated cell corrosion and is localized to a specific area. Pitting corrosion can be found on thin sheets of metal such as plated printed circuit board (PCB) paths, where the attack can be so severe that perforation of the plated PCB paths can occur.

Pitting usually occurs along grain boundaries and at porous finished areas on the metal. Porous gold plating on copper contacts is a common location for pitting corrosion. The plating pores create small corrosion



The mess in that panel at the left is in a Mooney that was parked by the ocean for several years. It took a full teardown to troubleshoot corrosion-related radio problems, including oxidized connectors. You don't want to see what could be lurking under antennas, top.

cells that continue to expand and deepen, forming a pit. Look at aging chrome wheels on a motorcycle or vehicle and you'll likely see signs of pitting, especially in salty locations.

Galvanic (or bimetallic) corrosion is an electromechanical process where one metal corrodes when it comes in electrical contact with another and an electrolyte. It's characterized by a buildup of corrosion deposits on the mating active (anoxic) surface. The rate of corrosion of a galvanic pair is a function of the difference between the reactivity of the metals. The farther apart two metals are on the galvanic series chart, the faster the active (anode) metal will corrode in the presence of the electrolyte. Get that?

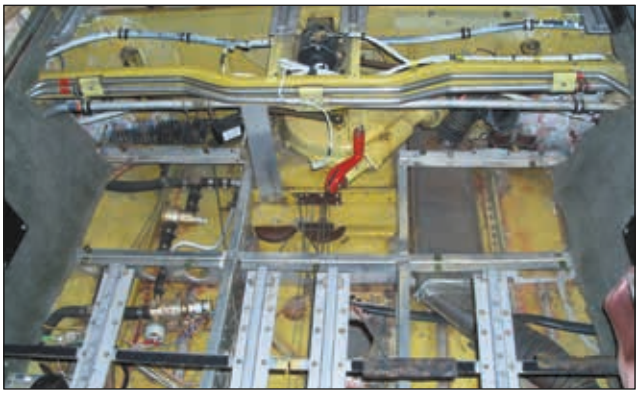
Intergranular corrosion is a chemical attack that occurs at the grain boundaries of a metal. A highly magnified view of a metal surface shows individual grains. Along the grain boundaries of the primary metal are individual grains of the metallic elements that make up the alloy. These other metals have a different corrosion potential than the primary metal. Often, the grain boundaries are anoxic and tend to corrode more easily than the grains of the primary metal. When an electrolyte is present, rapid selective corrosion at the grain boundary occurs.

One type of corrosion you can easily spot around steel fasteners, as one example, is exfoliation corrosion, which is an advanced form of intergranular corrosion. This causes the metal grains to separate at the grain boundaries due to the force of corrosive expansion. This is what makes the edges of an aluminum sheet swell or lift.

These are just a few examples of corrosion that attack electrical components in the aircraft and none are good. The best defense is offense.

LOOK IT OVER

Like preventing the spread of cancer, inspection is the best way to catch corrosion in avionics before it gets out of hand. This is especially important in corrosion-prone climates—including moist hangars. Unfortunately, the avionics system in even the simplest GA aircraft isn't easily accessed. If you've seen your panel torn open for an upgrade you know why. Focusing on problem areas is one place to start.



A common area for corrosion to build is on bulkhead connectors and fittings as shown in the top and middle photos. That's the wing root on a pressurized twin Cessna. Since avionics system wiring and components aren't limited to the radio stack, corrosion inspection should include eyeballing components that live under the floor section, botom.

More on that in a minute.

Important tools in every avionics technician's box are magnifying glasses, inspection mirrors and flashlights. You don't have to tear the radio stack apart to catch corrosion, although accessing the wiring and connectors is a good idea, especially if the aircraft hasn't seen an avionics upgrades in a while.

For starters, remove the radios from their mounting racks to inspect the rear connectors and the chassis. If you've never done this, it's a chore that can be simple or almost impossible, depending how tightly the radios are stacked. Many components, including Garmin and BendixKing radios, require a 3/32 hex wrench to loosen the locking mechanism, which is accessed on the bezel. Older Cessna/ARC components use a long flat-blade screwdriver.

Once you have the radio in your hand, look closely at the RF antenna connections on the back, also paying close attention to the main connectors—which are generally attached to PCBs inside the chassis. Some radios have forged cooling ports that attach to cooling hoses. Shine a flashlight inside the hole and see if you can spot corrosion.

If you spot light surface oxidation on an edge connector, use a simple pencil eraser and carefully erase it clean. ACF-50—a popular aerospace anti-corrosion penetrating fog—can sparingly be used for spot treatment. Lear Chemical (ACF-50's manufacturer) said the product is endorsed by 27 aircraft OEMs and meets Milspec performance criteria, plus it's recognized by the FAA as a suitable corrosion preventive. We've used the product on connectors and in other

It was an interesting idea to use outside ram air to cool avionics, but one that can cause nasty corrosion. That's an old radio air box and corroded scat tubing, top, and the ram air vent on the leading edge of a Bonanza wing, middle. An avionics cooling fan, bottom, is the better option.

areas of the airframe with positive results and you can source it online.

Use caution when reinstalling the radios because with some equipment it's easy to bend a contact pin when you slide the radio back into the mounting rack. If there's any doubt of your ability, grab an avionics tech for help.

Worth mentioning is that even nonmetallic materials can be subject to corrosion. Culprits include water intrusion, fungal growth and UV light damage.

WATER COOLING?

Water cooling is a tongue-in-cheek shop term we used for avionics cooling systems fed by outside ram air. Some believe it's better than nothing because heat can be a real problem for avionics reliability, even for otherwise modern equipment. Manufacturers wisely switched to surface-mounted circuit boards and modern designs that are engineered to draw less current, but radiant heat is the killer when it comes to longevity. Even though some avionics have internal fans, it's the buildup of standing heat that does the expensive damage in hot-weather ops.

That's why it's important to make sure the avionics cooling system is in top shape. It's tough to imagine, but neglected ones can be a source of corrosion.

While we always advocate the use of avionics cooling systems, we've forever frowned on systems that source outside air. This is a common system once used on older Beechcraft and other aircraft. The design is clever, but pretty crude and itself is susceptible to corrosion.

The theory is to capture ram air through a vent in the leading edge of a wing, pipe it through scat tubing and ultimately into a plastic cooling pack/air box. Once in the box (which is mounted to the side of the radio stack), the ram air is dissipated through small holes in the side of the assembly.

For one thing, the box gets in the way when you need to work on the radio stack. Plus, it hardly provides enough airflow to properly move stagnant air away from the radios. But it gets worse.

When flying through heavy rain, the potential for introducing water, small bugs and other contaminants into the system is a major concern. We've seen plenty of radio backplates and chassis assemblies coated with corrosion and ugly green crust due to water ingestion. Damage aside, it's hardly effective cooling. That's because outside ram cooling is useless when the aircraft is stationary, like when you're sitting in a baking runup area waiting for clearance on a 90-degree day.

In an experiment we did for a previous *Aviation Consumer* article on cooling fans, we measured a temperature of 160 degrees F in the middle of a Piper Arrow's radio stack. That's the ragged edge of small component failure, rendering the ram air cooling system essentially useless.

Eliminate the moisture-induced corrosion and consider installing an avionics cooling fan. By fighting the chimney effect (this is the buildup of radiant heat caused by units at the bottom of the radio stack), avionics cooling fans move standing hot air out the front of the stack. Your avionics may even be designed to work with a fan.

Many avionics units have an air fitting on the mounting rack designed for mating with a cooling hose. One cubic foot per minute of airflow at a pressure equal to .01 inches of water does the job. The beauty of an avionics cooling fan that's installed correctly is that it ingests dry cabin air and not moisture like ram air systems. Fans are available with single output ports or multiple ports to cool nearly all components in the stack.

For aftermarket retrofit, Garmin markets the three-port GFC314/328 series, which are the ACF series made by Sandia Aerospace and move 25 cubic feet of air per minute. These fans use reliable and quiet brushless motors that are rated for 78,000 hours of continuous operation.

Many shops prefer the Sandia/Garmin models because they are FAA

and PMA approved, eliminating the need for a silly field approval. Sandia also makes a large-capacity five-port model. We'll look at the avionics cooling fan market in an upcoming issue of *Aviation Consumer.*

ANTENNAS AND OTHER PROBLEM AREAS

One common problem is antenna systems and the way they're mounted to the aircraft skin. Antennas coated with fiberglass can crack around the base area and also around the screw mounting holes, which can collect water. We've seen some awful antenna installations done with shortcuts and poor prep work that invite corrosion down the road.

Along with manufacturer instructions, AC 43.13-2B has specific guidance for antenna work, but adherence to the advisory circular and instructions can vary by installer. A doubler plate strengthens the structure around the antenna so when the antenna vibrates in flight, it doesn't cause damage to the skin. That same vibration is also a setup for corrosion to form.

Fretting corrosion occurs when there is slight relative movement between two materials when an electrolyte is present. Fret corrosion is typical of close-fitting, highly loaded structures—like the antenna base and the aircraft skin.

While you probably won't easily spot corrosion that forms under an antenna, there are some clues. One thing you might try is moving the antenna, using caution to not stress the skin and/or crack the antenna. If there's any give or hint of looseness you should dig deeper, which includes inspecting the doubler plate. Any evidence of weeping or discoloration from the base of the antenna to where it meets the fuselage is a sign to check further for corrosion.

You know the saying about an ounce of prevention. Proper antenna installations should include stripping any corrosion and oxidation from the surface of the skin. This also creates a solid bond, which is key to good performance.

If the base gasket is deteriorated or the silicone seal is compromised the antenna should be removed, any corrosion treated and the antenna replaced. Chances are if there's sizable corrosion, the antenna has seen better days. We've seen installations where the antenna wasn't even sealed. It's almost a definite chance for eventual corrosion due to water intrusion around the base. Build enough corrosion and you might pay for an expensive skin repair.

Some areas of the aircraft (especially the tail) are essentially in a constant bath of moisture and dirt, which promotes corrosion. You might not give it a second look during preflight inspections (plus, you'll need a ladder to access it), but VOR antennas have splitters and baluns that are often mounted in the tail, poorly protected by fairings. If you've ever chased a VOR reception problem, the culprit was likely corrosion built up on the antenna system. Corrosion can reduce receiver performance or cause intermittent reception as the corrosion worsens.

In many cases, the only way you'll be able to properly inspect the system is to remove inspection plates and tail fairings and look for signs of moisture intrusion and resulting corrosion.

Other problem areas include RF antenna connectors and also grounding straps, which are placed around the airframe. Grounding straps electrically join control surfaces to the fuselage. Corrosion can contribute to decreased radio performance and RFI, or radio frequency interference. Coaxial cable connectors are also subject to corrosion and we think they're worth replacing when installing new antennas. After all, they're right in the technician's hands, which is the best time to change them.

TIPS FOR TAMING AVIONICS CORROSION

- ✔ Periodically remove the radios and inspect the connectors.
- ✔ Gently remove connector corrosion with an eraser.
- ✔ Sparingly treat problem areas with anti-corrosion spray.
- ✔ Remove the tail fairing and inspect the nav antenna system.
- ✔ Remove ram air cooling systems and invest in a cooling fan.
- ✔ Cracked antennas and missing sealant could mean corrosion.
- ✔ Use a dehumidifier when storing the aircraft for long periods.
- ✔ Better, remove and store the radios in a climate-controlled area.

CONCLUSION

These days, avionics manufacturers consider corrosion when designing components, using sealed connectors when appropropriate. More than one shop told us it's seeing more avionics corrosion when it opens up panels for major retrofits. That makes sense because these days more aircraft sit for long periods of time. Plus, the fleet is getting older and with age comes corrosion, especially in salt-prone climates.

Avionics corrosion control isn't difficult when caught early. That means proactive replacement of antennas and connectors, upgrading the avionics cooling system and storing the aircraft in dry locations.

ReliefBand Watch: Still Tops For Sickness

It's pricey, but the FDA-cleared ReliefBand could be the simplest remedy for queasy passengers. It's drug free, so it's fair game for crew and while flying aerobatics.

by Larry Anglisano

I've turned down rides in cool warbirds and open-cockpit aerobats because once I got pretty sick doing aerobatics—and I was the one on the controls. For me, the rotten experience makes the ReliefBand therapeutic watch worth the $95.

Moreover, the price is better than cleaning the aircraft upholstery (you'll never get it like new) when a passenger loses a $100 hamburger. I recently ordered a new ReliefBand to replace an older model, and learned of a next-gen replacement that's in the works. Here's a field report.

I DON'T FEEL SO GOOD

Brent Blue, our resourceful go-to M.D., tells me motion sickness is a learned process that can be unlearned. While that useful tidbit won't help when a passenger does a technicolor yawn at 10,000 feet, motion sickness seems easily treatable with the right approach and remedy. More on the remedy in a second.

There is more to motion sickness than puking and we've all felt the symptoms regardless if motion was involved. It might include a headache, cold sweats, increased salivation, burping and flatulence—none of which are well matched for the confines of a small aircraft cabin. The cause? It's fairly complicated.

Without going deep into medical theory, human balance and spatial orientation (or lack of) are determined in the brain, central nervous system, the eyes and the three liquid-filled tubes of the inner ear. One clinician I talked with simply described motion sickness as sensory overload as the fluids in the ear canals move. But the important aspect is the sensory conflict between actual orientation and what is anticipated. In other words, you're along for the ride without input or anticipation.

The symptoms can worsen when there's no outside visual reference. Doc Blue noted that even low levels of carbon monoxide will lower the threshold for motion sickness.

NEUROMODULATION

Hardly new to the market, the ReliefBand is a wearable therapeutic neuromodulation device. It electrically stimulates the median nerve in the wrist with an electrode that's built into the bottom of the watch-like transmitter. The median nerve is at the same location acupuncture needles and therapeutic bands are placed when treating nausea. When the first ReliefBand was released somewhere in the mid-1990s, it required a prescription, and the product changed hands a couple of times before Horsham, Pennsylvania-based ReliefBand Technolgies bought the brand a couple of years ago. The device is hardly limited to aviation activities, although the company said it's been tested with good success by U.S. Air Force crews.

Jackie Simon, ReliefBand's chief medical officer, said it's cleared by the FDA to treat the symptoms of motion sickness, morning sickness and vertigo, plus it's used for clinical

The ReliefBand, lower left, has a dated clinical look and feel, but the next-generation Neurowave model, lower right, resembles a sleak fitness device. It has a modern band, a digital display and is expected by the end of 2017.

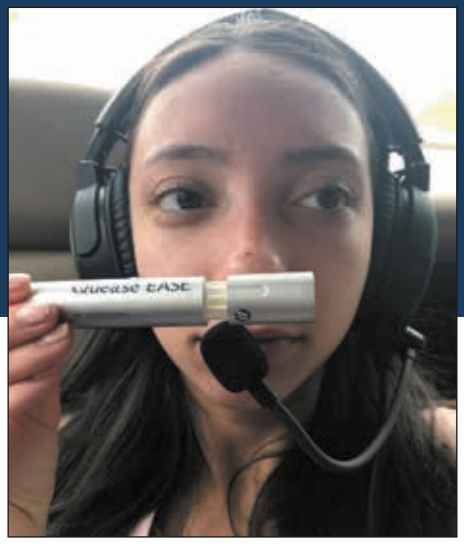
SICKNESS REMEDIES, TIPS AND THEORIES

Years ago while motoring through the New York Class B in a Mooney, I turned around to find my motion sickness-prone wife slouched down, eyes closed and head resting 90 degrees on the rear sidewall. Just as I was thinking it wasn't the ideal seating position she authoritatively christened the Mooney's fabric seats. Yes, I failed to brief her on where the relief bag was. That forever changed my approach to passenger briefings and air sickness preparedness, which should include at least some advice and tips for keeping it together.

First, posture. I asked Dr. Brent Blue if seating position makes a difference in fighting motion sickness and according to him, it certainly does play a role. "Head position definitely can have an effect on air sickness because it has to do with the orientation of the semicircular canals in the inner ear," he told me. If you can seat a passenger up front, those who suffer from motion sickness might do better because there's less yaw effect and better visibility, Blue suggested. Supplemental oxygen, plus scopolamine patches applied at least an hour prior to flight, can help too. For some, ginger may help.

To supplement the ReliefBand report, I had Sporty's send other remedies from its inventory of sickness products, including the $10 QueaseEase product, which I also spotted in a few drugstores. The inexpensive QueaseEase is drug free and contains a blend of natural essential oils including ginger, peppermint, spearmint and lavender. The recipe is stored in a convenient cylinder with a twist cap (see the image below) that releases the scent. According to the company, the molecules from the inhaled oil scent travel to the central nervous system where they break the queasiness cycle. Passengers liked its odor.

As for medicine, there are none that I know of that are legal to use while PIC. For passengers, Zofran is said to be a good anti-nausea/vomiting med if taken prior to exposure.



As for pilots like me who battle nausea during aerobatics, Brent Blue is convinced the ReliefBand can "unlearn" motion sickness. The theory is that unlike millennials who grew up with modern car seats that enable vision out the front and sides of the vehicle, my motion sickness was learned in the bad old days before car seats. Regardless, the key is to have a solid plan in place should you or your passengers fall ill.

post-op and during chemotherapy treatments. Using it is pretty simple. For those prone to motion sickness from flying, Simon suggests using it up to 30 minutes prior to flight, plus you can wear it for as long as the symptoms last. The only potential side effects from the device (which has a published maximum output of 35 mA) is skin irritation around the area of the device's electrode.

The ReliefBand is worn on the underside of the wrist. You know it's transmitting because you'll feel a slight tingling sensation in the wrist and middle fingers as you're zapped every four seconds. For best performance, the device comes with a tube of hypoallergenic conductivity gel, which can help when used on dry skin. The splash-resistant (but not submersible) ReliefBand runs on two CR2025 lithium batteries that last roughly 150 hours at medium intensity. A battery life annunciator is located on the face of the device and comes on when there is roughly 10 hours of battery life remaining.

The current ReliefBand differs from older models because it has a five-intensity stimulation feature. The intensity (five being the highest) is adjusted with a button on the center of the face, which also serves as a power button. Flashing annunciators show the current setting. The multiple settings are not for various degrees of sickness. Instead, since the median nerve isn't in the exact location on every person's wrist (deep in some, shallow in others), it might require higher amounts of therapy to effectively reach the nerve.

Body mass doesn't seem to matter. Larger people could have a median nerve closer to the skin's surface than thinner ones. Again, you'll know the signal is reaching the nerve when you feel a tingle. I think the variable stimulation feature is a good improvement.

HOW EFFECTIVE?

Can everyone count on the ReliefBand all the time? Simon reasoned that no drug is 100 percent effective for the entire population and similarly, the ReliefBand's therapeutic effectiveness isn't perfect, either. She said the device has an 80 to 85 percent efficacy rate amongst all populations. During my research I spoke with other pilots, including aerobatic flight instructors, and everyone who's used the ReliefBand for themselves or for students and passengers reports extremely favorable results. The couple of passengers who used my ReliefBand sample generally don't get motion sickness. Given the efficacy rate, you really won't know until you try it.

The ReliefBand, which has a street price of around $95 (Sporty's selling price), doesn't exactly have a cutting-edge appearance; it was born in the clinic a long time ago. The next-gen ReliefBand, called the Neurowave, was recently unveiled at the recent Consumer Electronics Show. It works nearly the same as the current model, but has a redesigned non-latex band, a digital feature set, rechargeable batteries and it resembles a fitness tracker. The modern design could be more appealing to nervous passengers and more inconspicuous when worn by crew. The Neurowave—which will be FDA cleared—is expected to sell for just under $200 when it's released later this year.

CONTACT...

ReliefBand Medical Technologies
877-735-2263
www.reliefband.com

Diamond DA40

Whether for training or traveling, the DA40 has modern ergos, efficiency and a stellar safety record.

Photo courtesy Diamond Aircraft

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

There's a lot to like in a DA40. The canopy provides superb visibility, the speed is impressive—newer models are even faster—and handling is just plain fun. When we fly a DA40 after a hiatus, we marvel at the control harmonization and how easy it is to land in gusty crosswinds.

Don't let the exterior fool you. The DA40's cabin is roomier than it looks, plus it has control sticks instead of panel-blocking yokes.

Even better, the wreck reports—what few there are—don't reveal anything horrible about the DA40, save for a few horrible outcomes when DA40 pilots do silly things. Still, the DA40 seems to have the best safety record of any aircraft we researched.

HISTORY OF THE LINE

Hoffmann 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 Hoffmann 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.

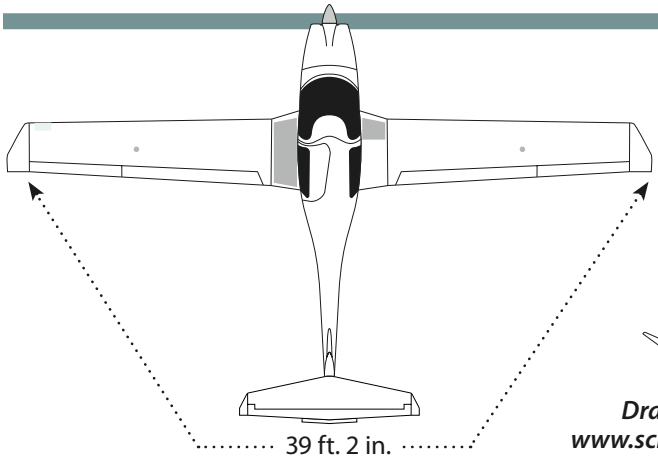
Statistically, the DA40 is one of safest GA aircraft flying, both by accident rate and fatal rate.

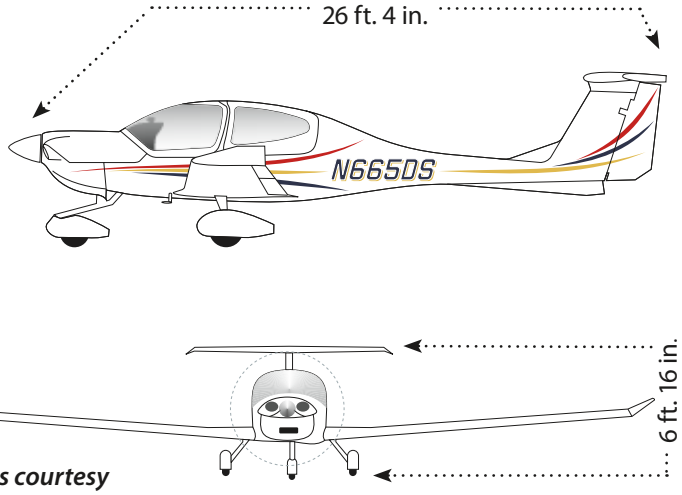
Diamond—then called Dimona—got its feet wet in the U.S. market by importing the Austrian-built DV20 Katana. In 1995, it began building Rotax-powered DA20-A1s in the London plant and selling these into what was then a lukewarm market for new trainers. By the time the company changed its name from Dimona 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

You don't have to look closely at a DA40 to see its sailplane-inspired design. That's a DA40 XLS in the lead photo.

DIAMOND DA40 SERIES



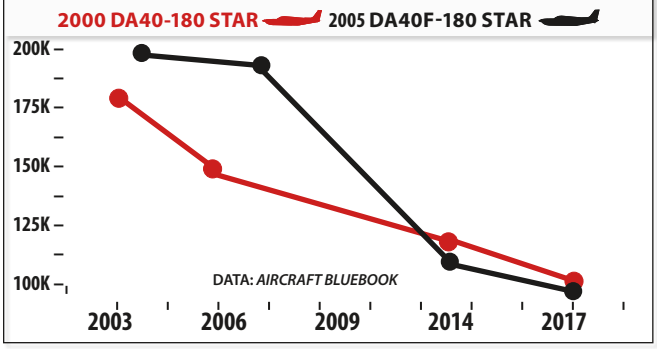


Drawings courtesy www.schemedesigners.com

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	40	915 LBS	145 KTS	±$95,000
2004 DA40-180 STAR	LYCOMING IO-360-M1A	2000	$25,000	40	915 LBS	145 KTS	±$115,000
2005 DA40F-180 STAR	LYCOMING O-360-A4M	2000	$23,000	40	915 LBS	135 KTS	±$90,000
2006 DA40-180 STAR	LYCOMING IO-360-M1A	2000	$25,000	40	915 LBS	145 KTS	±$135,000
2006 DA40F-180 STAR	LYCOMING O-360-A4M	2000	$23,000	40	915 LBS	135 KTS	±$95,000
2007 DA40F-180 STAR	LYCOMING O-360-A4M	2000	$23,000	40	915 LBS	135 KTS	±$105,000
2007 DA40-XL STAR	LYCOMING IO-360-M1A	2000	$25,000	40	860 LBS	150 KTS	±$195,000
2011 DA40-XLS STAR	LYCOMING IO-360-M1A	2000	$25,000	50	860 LBS	150 KTS	±$265,000
2013 DA40-XLS STAR	LYCOMING IO-360-M1A	2000	$25,000	50	860 LBS	150 KTS	±$330,800
2014-15 DA40-XLT STAR	LYCOMING IO-360-M1A	2000	$25,000	50	860 LBS	150 KTS	±$430,000

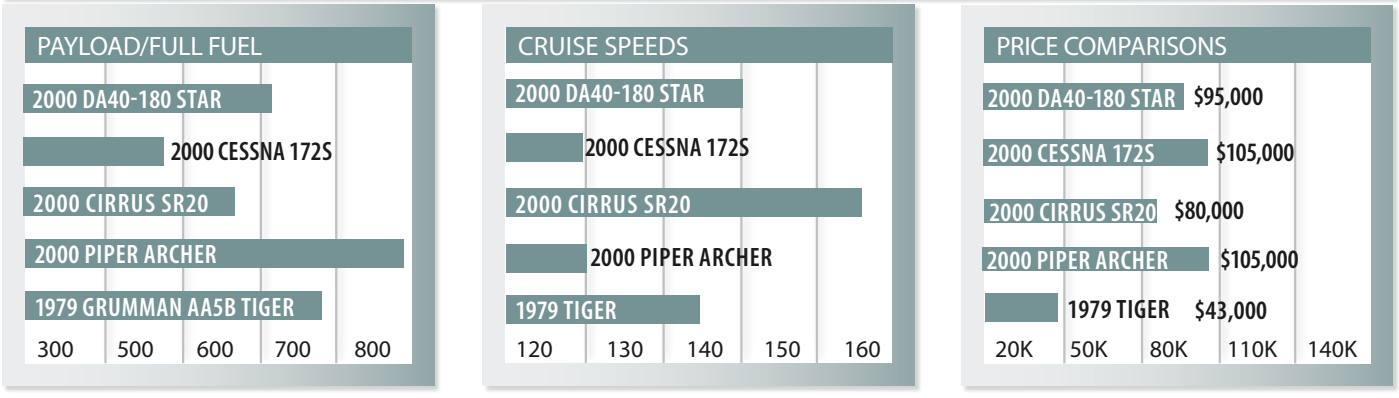
DIAMOND DA40 RESALE VALUE



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 LATER-MODEL COMPARISONS



The first application for Garmin's G1000, top, came to the DA40 in 2004, while prior Stars had steam gauges, Garmin GNS navigators and the BendixKing KAP140 autopilot, bottom.

and a year later, production began in the London plant. Sales were initially brisk, especially to the trainer market which, increasingly, 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 BendixKing 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, Power Flow 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 à 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 Hoffmann, 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 that 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 that 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 castering 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 pedals 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.

In 2014, Diamond brought the DA40 NG to market. Equipped with the 168-HP Austro AE300 diesel engine, the current Aircraft Bluebook shows a 2015 model retailing for $435,000. The engine has an 1800-hour TBO and a $30,000 typical overhaul cost.

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 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 is an aftermarket option in the DA40s. 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, although some owners have found their own fixes for this.

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 level—is faster by about 10 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 (2645 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

The core of the Premier Edition enhancement is an upgraded interior, top. The baggage area was later redesigned to include fold-down rear seats, middle, but early Stars offered a small baggage area and storage tube for larger items, bottom.

DA40 ACCIDENTS: ASTONISHINGLY FEW

Every month for the Used Aircraft Guide, we pull up the most recent 100 reported U.S. accidents for the type of airplane we are reviewing. It's usually no big deal—even if we have to go back 20 years, there are almost invariably well over 100 accidents for a given type, even if most are of the fender-bender variety.

That's not the case for Diamond's DA40 Star. We looked back to the year of the DA40's certification, 2000, and found 18 reported accidents in the U.S. out of what we conservatively believe to be approximately 800 airplanes. In our opinion, that's nothing short of stunning. Six of the accidents were runway loss of control (RLOC) events—one on takeoff—and one was an overshot landing. We consider those to be run-of-the-mill accidents and the low number a tribute to good ground manners on the airplane's part during takeoff and landing. When we first flew the airplane shortly after it came out, we noted how well it handled strong crosswinds—the absence of landing accidents bears out our observation.

With so many airplanes flying, we assumed we'd see at least 10 stupid pilot trick impacts against terra firma or power lines. There have only been five. One hold-my-beer-and-watch-this sort was buzzing boats on a lake at dusk and hit the water; one was maneuvering at low altitude and crashed; an instrument pilot shot an approach to several hundred feet below minimums and hit power lines and trees; and a pilot who decided to fly in icing conditions picked up so much that when he finally decided to descend and find a place to land, he stalled the airplane at 1000 feet AGL and survived the crash. The DA40 again demonstrated excellent crashworthy design when an optimist with a load of passengers decided to fly low and search for elk. All went well until they turned into a blind canyon. Unable to turn around or climb over the terrain, the pilot stalled the airplane into the rising terrain. Two passengers walked away with minor injuries; the other two had no injuries.

There were two VFR into IMC crashes. One non-instrument pilot made the decision to take off into fog—at night. He was able to climb to his cruising altitude and call ATC for flight following before he said he was in trouble. The airplane spiraled into the ground. The other pilot tried to scud run through IMC and hit terrain.

There was one midair collision and one birdstrike.

Despite having an amazingly low accident rate, the DA40 is not invulnerable—it does need the amount of runway set out in the performance section of the POH for takeoff. A pilot with a full boat of passengers started his takeoff roll on an uphill grass runway with obstructions at the end. The POH data indicated that the airplane would need 1570 feet to clear a 50-foot obstruction on a takeoff from level pavement. In this case, the airplane apparently beat its book performance as it hit the tops of trees and a set of power lines a mere 1,150 feet from the beginning of the takeoff roll. It just didn't beat book by enough to satisfy the demands of the person in the left front seat.

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 backseat into one huge baggage bay.

The Star's weight-and-balance envelope is relatively benign, narrowing a bit toward the gross weight limit. Early models tend 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, but the rudder pedals adjust. A 6-foot-5-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 the 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/Evolution/Eclipse 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

That's Will Hubin's 2008 DA40 in the top photo. Hubin—a 6000-hour pilot and CFI—believes it's the easiest to land of any GA airplane he's flown.

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, MODS

Typically, airplanes new to the market (although at this point the DA40 has been around for a while) evidence characteristic maintenance weaknesses at some point. But historically 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, save for a few owners who had problems with electric fuel pumps.

Some owners complained of early teething problems with the Garmin G1000. We also heard plenty of complaints about Garmin being slow to produce software upgrades for non-WAAS aircraft. 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.

As for aftermarket mods, there aren't many. Florida-based Premier Aircraft (also a Diamond dealer) offers the Cabin Cool air conditioning system, the PowerPlus standby alternator system and a stylish and functional interior upgrade package. There's a also a custom exterior striping package, plus for better climb and couple extra knots in cruise, a Hartzell ASC composite propeller is available. Contact www.flypas.com.

OWNER FEEDBACK

I purchased a 2008 DA40 XLS in January 2013, after cross-shopping with a newer Cessna 182T and an upgraded model 35 Bonanza. I am based at RHV in San Jose, California, and currently have 1750 delightful hours in this aircraft, which just passed 2000 hours of flight time. Most of our flights are under 400 miles with longer annual excursions to Seattle, Baja and Oshkosh. The sweet-spot altitudes are between 8000 and 11,000 feet and on trips we plan for 140 KTAS at 8 GPH.

My 2008 has the Garmin G1000 with the GFC700, making it an excellent platform for coastal IFR to low minimums. We average about 45 IMC approaches each year. I much prefer the standby instruments located at the top of the control panel, rather than down by the knees.

My goal was to buy a safe, practical and fun IFR aircraft that carries three adults, with low enough operating costs that my inner cheapskate would not inhibit flying. Our ownership experience has greatly exceeded expectations, and I fly more often than originally planned. The purchase was a one-time gouge in our

finances, but at this point it costs less to fly for an hour than a trip to the hardware store, plus it's safer than an hour on winding roads in our Mazda Miata and way more fun.

The only significant downside to the DA40 is the limited useful load, at roughly 850 pounds. But with 140 KTAS on 8 GPH, 30 gallons of 100LL works for two couples and day packs. It has outstanding visibility for sightseeing and traffic detection, plus everybody in the aircraft loves the view. The flip side of the glorious view is heat buildup while on the ground, but latching the canopy slightly open until just before takeoff makes this manageable. The controls are responsive and nicely balanced. I suspect the benign handling contributes to the DA40's stellar safety record. The aluminum fuel tanks between carbon-fiber wing spars resist post-crash fire.

I'm sure that an airframe parachute would provide bonus marketing points (especially with all-important non-pilots), but with an already best-in-GA safety record, I personally don't think that the cost in weight and maintenance makes sense. In my view, all of the DA40 fatalities in North America are due to colossal pilot error. The few fatalities are due to what-were-you-thinking mistakes.

Flown correctly, the DA40 is a pussycat around a gusty runway. Note the good forward and side visibility in the cam view above.

Maximum speed is 155 KTAS, but nobody regularly pushes it that hard given the increase in engine heat, plus fuel consumption jumps 25 percent compared to the slower and more typical 140 knots. If speed is at the top of your agenda, buy a different airplane. Still, the DA40 has good climb rates all the way into the teens.

The center stick intrudes in usable space, but I greatly prefer a stick with actual (not spring-loaded) feedback, and love flying the DA40 by hand. The seat height is not adjustable, but cushions from Oregon Aero (www.oregonaero.com) work very well.

My DA40's financial summary since 2013 (roughly 1700 hours) is $4.55 per hour ($7750 total) in repairs, which includes self-inflicted wheelpant damage after landing on a poorly plowed runway. I also replaced the Duke's fuel pump with a Weldon pump, replaced the Sky-Tec starter, resealed the Hartzell propeller and replaced the G1000 MFD because of a defective SD card slot.

All other maintenance is around $16,000 total. I do my own oil changes and replace the tires and brakes. Owner-assisted annuals are roughly $1550, insurance is $2600 per year with $2 million smooth coverage, while navigation data and SXM subscription is $1400 per year.

Upgrades include AeroLED Pulsar MSP strobe and position lighting and a Plane-Power alternator, which provides higher output at idle power and kills the low voltage alerts in the G1000. I also installed the Electroair electronic ignition. Combined with the GAMI fuel injectors, the engine runs extremely smooth at LOP.

DAN (www.diamondaviators.net) is an excellent source of information. DAN is not affiliated with Diamond Aircraft, and is a remarkably flame-free environment. DAN was instrumental in my decision to buy a DA40. I was able to get balanced and detailed information in order to make an informed decision.

I think the DA40 is an aircraft that more people should consider. Recent models with the G1000 and GFC700 autopilot are pricey, but older DA40s are an excellent value. The airframe is not life-limited, plus the Lycoming IO-360 is robust and ubiquitous. I physically don't fit in a pre-2008 model (long torso), otherwise I would have seriously considered an older plane.

Chris Bennett
San Jose, California

I've owned my 2003 DA40 for about eight months, but have been flying it for over five years. My criteria as a first-time aircraft owner who is not mechanically inclined and would be

operating the aircraft on a retirement income were, in order: safety, efficiency, maintenance, useful load, comfort and other considerations.

My mission is regional (150- to 300-NM) Angel Flights and personal travel with three people or dogs in light IFR. I chose the DA40 because it came out the best by far on these criteria and it's simply fun to fly. Statistically, the DA40 is the safest GA aircraft flying, both by accident rate and fatal rate. It has a low stall speed, no difficult landing characteristics, is very stable and has never had a post-crash fire. Mine cruises at 135 knots at 7.9 GPH LOP, which is 17 NMPG or almost 20 MPG.

The Lycoming IO-360 engine is as close to bulletproof as you can get and the aircraft has simple systems to maintain. By adding the stronger main landing gear, the useful load is now 945 pounds, which equates to 705 pounds with full (40 gallon) tanks. Absolute comfort is not its strength, but it's still acceptable. The cockpit is small, but relatively wide and the canopy and back door provide easy access.

It's comfortably warm in winter, but can be hot in summer. The long wing does means some bumps in turbulence. Finally, the DA40 offers panoramic views, as well decent downward visibility since the pilot sits ahead of the wing. All in all, I've been satisfied so far.

Bernie Seward
via email

Ever since buying a Super Decathlon in 1995 I've been saving for a four-place airplane that would be a better cross-country machine. The Cessna 172 and 182 were either too expensive or not very available with updated avionics, plus they were too ordinary. I looked at a 2004 Grumman Tiger AG-5B equipped with a Garmin GNS530 and GNS430 and made a couple of bids for it. I liked the fact that it had good radios and a carbureted version of my Decathlon and I liked its canopy access and its extra speed, but I didn't like that it hadn't been flown much at all for almost a year. When the seller wouldn't reduce the price as much as I thought reasonable and there weren't other comparable Tigers available, I looked at the Diamond, which I had never flown.

My 2008 DA40 had only 500 engine hours and was loaded. It had the G1000 suite with WAAS and Garmin SVT synthetic vision, GFC700 autopilot, traffic alerting, airbags, three-blade MT propeller, Power Flow tuned exhaust system, plus the same fuel-injected IO-360 as my Decathlon. I was thoroughly seduced by the looks of the airplane. I bought it in April of 2015 and have flown it about 175 hours since.

I love the wonderful ground visibility with the large canopy as well as being able to step down into it from both sides, rather than sliding into it sideways. It can be hot inside the cabin, but being able to lock the canopy partway up is a lifesaver on the ground and the air vents work well in the air. It is plenty warm for flying at temperatures below freezing, too.

I don't like a non-steerable nosewheel, but I've lived with it before and I do love the low maintenance and lack of nosewheel shimmy. It does make it pretty difficult for one person to move it backward into a hangar, including the fact that it is offset from the center and wants to "jackknife," so I have an electric tug that does a nice job, even with a 40-foot-wide hangar door—and the 38-foot-plus wingspan.

The airplane came with power jacks for Bose headsets, which I very much like, but they are on the sides of the fuselage rather than in the center, so they are a hassle to get out of the way when stepping in the cabin. It may be the quietest plane I've flown and the seats are very comfortable for me.

With its cushioning landing gear, the DA40 may be the easiest plane to land that I've flown (among dozens as a 6000-hour pilot and CFI) and a complete contrast to the Decathlon, which delights in returning one back into the air with almost any excuse. Doing stalls, I gave it every chance to try to depart, but the stall strips must really work because it refuses.

The wheelpants help give it efficient cruise speeds, but are made of light fiberglass and susceptible to damage. One was damaged when the tire went flat and another when a taxiway wasn't properly cleared of hardening snow. Fortunately, the paint shop on the field did a fine

The Aviation Consumer

Diamond DA40

(continued from page 31)

repair. I don't want to taxi over rough grass.

I have the 50-gallon fuel tanks which I like, but they give a small useful load when full and they do reduce the allowable loading range.

The first annual inspection I dealt with cost $1093 and the second was $1480, with the additional cost due to removal and inspection of the Power Flow exhaust. No significant issues were found on either annual. I paid $3181 last year for full insurance coverage on both the Diamond and the Decathlon, at the age of 78.

Will Hubin
via email

Based on our extensive Diamond sales experience, here are some things buyers should consider when looking for a used DA40. First, consider that a 2017 DA40 is north of $450,000. There are a wide range of used model prices ($150,000 to $450,000), which gets you into a modern aircraft no matter the vintage. The 2000 to 2003 vintage DA40 may be for the budget minded. These airplanes have round gauges and are generally priced between $100,000 to $125,000.

Worth mentioning is that you shouldn't dismiss former training aircraft. If purchased right, these DA40s are good candidates for refurbishment and are generally priced at least 10 percent less than an equivalent non-training aircraft.

The 2004 to 2006 are early Garmin G1000 DA40 models and are generally priced between $140,000 and $170,000. But you should consider that these older G1000 systems may require sizable upkeep, including flat-rate component exchange or factory repairs due to age.

The 2007 DA40 XL models have the desirable GFC700 integrated autopilot, Power Flow exhaust system, three-blade propeller and are generally priced in the $180,000 to $200,00 range.

The 2008 to 2010 DA40 XLS have WAAS G1000 systems and might be priced between $225,000 and $260,000. A new interior was introduced in the 2013 DA40 XLT.

Insurance for a DA40 is relatively inexpensive compared to other models, and even student pilots generally don't faces challenges getting insured.

Upgrading an older G1000 DA40 to WAAS will be a sizable expense. Typically this is around $25,000, while mandate-compliant ADS-B upgrades range from $3000 to $10,000, depending on the equipment and the capability.

You'll ideally want to purchase a DA40 that has been maintained by an authorized Diamond service center. Do an exhaustive check of the aircraft logbooks to ensure all ADs and service bulletins have been complied with, while looking hard for evidence of damage history and noting who did the repairs. Luckily, there are limited ADs on the DA40. Nosegear struts and main spar skin bonding are important ones.

As for inspections, the Power Flow exhaust inspection is required yearly or every 500 hours, the 1000-hour inspection can run $5000 to $6000 and the 2000-hour spar bridge inspection is relatively minor at a few hundred dollars, generally.

One of the great features of the composite DA40 is that periodic washing and waxing can keep it looking new for a long time, while the airframe is fairly tolerant to damage.

Cathy Ahles, Premier Aircraft Sales
Fort Lauderdale, Florida

That's the air scoop for the CabinCool air conditioning.

FEEDBACK WANTED

V-TAIL BONANZA

It's time for a fresh look at the Beechcraft V-tail Bonanza for the Used Aircraft Guide in an upcoming issue of *Aviation Consumer.* We want to know what it's like to own these aircraft, how much they cost to operate, maintain and insure and what they're like to fly. If you'd like your airplane to appear in the magazine, send us any photographs (**full-size, high-resolution please**) you'd like to share to the email below. We welcome information on mods, operating expenses or any other comments. Send correspondence by August 1, 2017, to:

Aviation Consumer
Email at:
ConsumerEditor@hotmail.com