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FEATURE

ACTUALLY ~~In~~accurate

CIES SENSORS PROVIDE RELIABLE FUEL LEVEL READINGS

BY BETH E. STANTON

ACTUALLY ACCURATE

"IT'S VERY STRANGE," SAID SCOTT PHILIBEN, EAA 1148835, CEO AND FOUNDER OF CIES. "THIS ISSUE HAS BEEN AROUND FOR A VERY LONG TIME. PRACTICALLY EVERY MOVIE FEATURING A STRESSED-OUT PILOT INCLUDES THE OBLIGATORY TAPPING OF THE FUEL GAUGE."

In airplanes, fuel sloshes around in long, shallow tanks, creating motion that creates sporadic contact with the sensors in the tank. This results in notorious inaccuracy and the classic windshield wiper motion seen with most fuel gauge needles.

"Like your tachometer, the fuel gauge is a component that really ought to work," he said. "Then we came up with these statements that make no sense, like that it only has to be accurate at zero. Well, if your tachometer were only accurate at zero, it would be a broken tachometer. There were a whole bunch of reasons people dreamed up to say this problem couldn't be solved, and we, the aviation community, never really did anything about it."

In 2012, Cirrus Aircraft asked Scott to take a shot at the problem of fuel level indication. In response, he developed and patented a relatively simple system using a non-contact position sensor using magnetic field technology. He paired this new technology with the same float mechanism found on many GA aircraft. The system is highly accurate, indicating changes in fuel levels less than 0.03 of an inch, which represents much less than a tenth of a gallon of fuel.

"Heads were spinning," Scott said. "The most hated, reviled, untrusted instrument in the aircraft all of a sudden is now the most reliable instrument in the aircraft. It's a total phase change."

SOLVING THE PROBLEM

TO SOLVE THE PROBLEM, Scott and his team mounted a variety of fuel sender technologies in a wing-shaped Plexiglas tank and motored this contraption around on a boat. These experiments allowed them a clear view of the dynamics that fuel senders endure and why they commonly fail in aircraft.

Methodically, they defined the criteria of an ideal sender. After evaluating choices against those criteria, a solution began to emerge.

"It was sort of like the old computers from the 1960s that spit out the one final data card that had a single solution on it," Scott said.

After observing its performance, they determined that a float was advantageous in aviation applications in several ways. It reliably found the fuel surface and provided mechanical damping. To more closely simulate the aircraft environment, they simulated prop wash by using a shaker that agitated the volume in the tank. With so many float senders already used in aviation, a retrofit product that matched the geometry of a replaced sender could be used in many aircraft.

"We can use a float, but we wanted to find a better way to measure its position in the tank," Scott said.

MAGNETIC FIELD SENSOR TECHNOLOGY

THE CiES magnetic field sensor technology can be described as a compass with the float on the surface of the fuel as magnetic north. Electrical properties of ferromagnetic alloys, in this case, silicon iron doped on a chip, are influenced by external magnetic fields. By including a magnet at a pivot point, this phenomenon can be used to measure angles. Wherever the fuel moves in the tank, the fuel level sender always points to the float on the surface of that fuel.

This technology uses high-reliability, non-contact sensors that don't have to touch anything to measure angular position. This feature allows for a safe system that eliminates the hazards associated with fuel tank electrical contact. The sensors can measure 180 degrees, as opposed to the 60-to-70-degree range of a typical potentiometer used in legacy senders. This full measurement range is controlled by software and allows for a simpler sender configuration. A microprocessor provides a digital output to interface with computer-based instrumentation, as well as an analog output to simulate resistive output to analog gauges in the legacy fleet.

CiES also sought to fix the problem with legacy senders that use steel in the sender body. When combined with a typical aluminum tank, steel encourages rust and corrosion after contact with moisture. Not only are corrosion and corrosion particles bad for aircraft fuel systems, but they also can lead to failure or inaccuracies in indicated fuel quantities.

"Half of the fuel senders we see look like they came from the Titanic," Scott said.

CiES system components are non-corroding Teflon hard coat anodized aluminum composed of an outer housing, circuit card, receptacle cap unit that holds the circuit card in the housing, a rotor with magnets, arm, and float. A stainless pin holds the parts together.

FLEXIBLE DESIGN

CiES MANUFACTURES its sensors for original equipment manufacturers, small and medium aircraft, rotorcraft, as well as a small market in marine and specialty automotive applications. They are approved by both the FAA and EASA. CiES holds an STC that applies to large numbers of GA aircraft that weigh less than 12,500 pounds to replace the existing fuel quantity senders in multiple models of Cessna, Beechcraft, Cirrus, Mooney, and Piper, along with about a dozen others.

This flexibility is best illustrated in that CiES supported the Ford Tri-Motor application and its three large tanks by adapting senders used for the Airbus AS350 B3 helicopter.

"We're pretty flexible," Scott said. "We can modify our design to suit any application. Most GA aircraft have wings that are anywhere from 4 to 8 inches deep, and the number of variations is not as great as you would think."

One of the first manufacturers to approach CiES after Cirrus was Britten-Norman looking for a solution for the Islander.

"We designed it, and it is funny to us that now about 30 aircraft use the 'Britten-Norman arm,'" he said. "It's the running joke around here."

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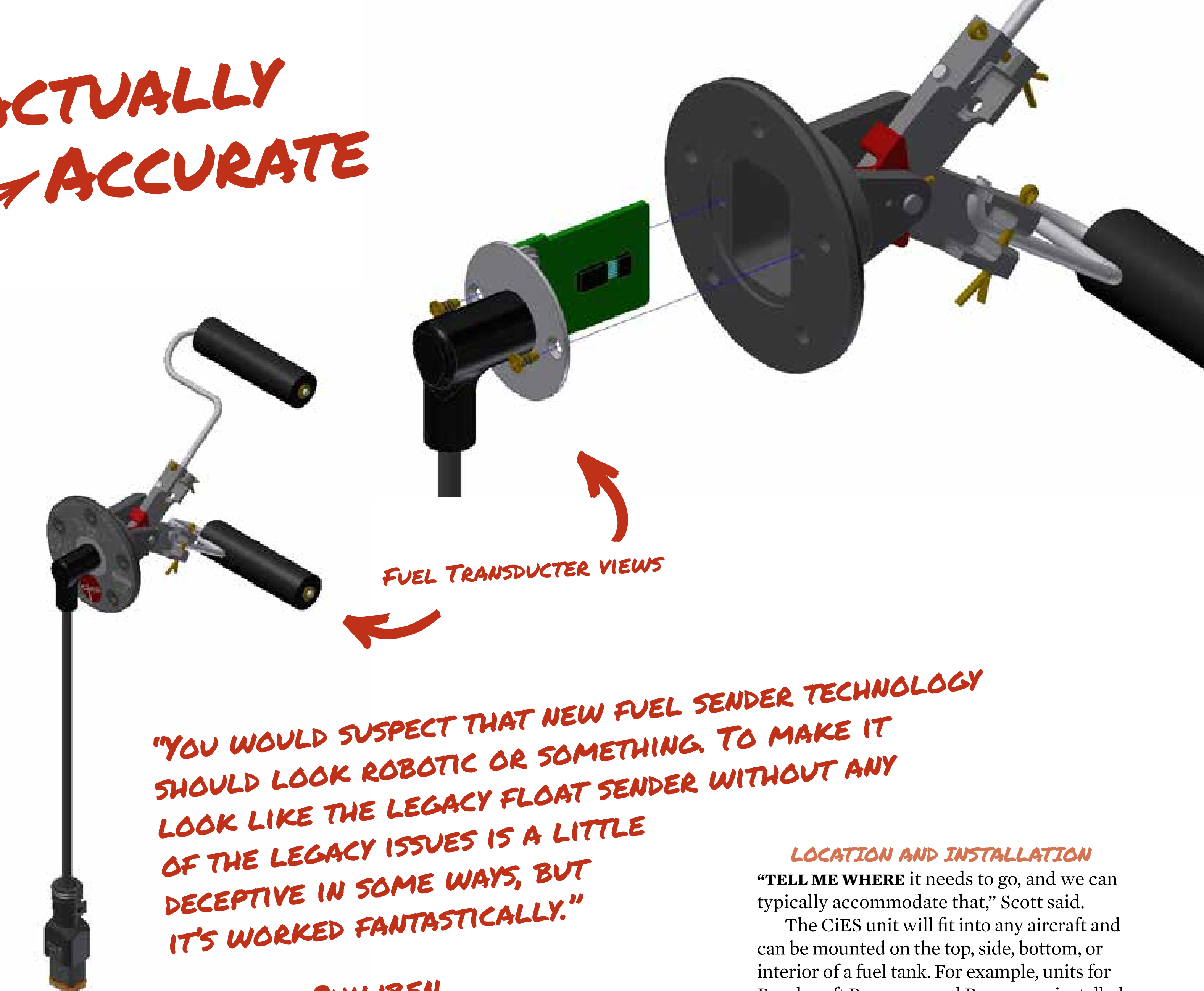

"YOU WOULD SUSPECT THAT NEW FUEL SENDER TECHNOLOGY SHOULD LOOK ROBOTIC OR SOMETHING. TO MAKE IT LOOK LIKE THE LEGACY FLOAT SENDER WITHOUT ANY OF THE LEGACY ISSUES IS A LITTLE DECEPTIVE IN SOME WAYS, BUT IT'S WORKED FANTASTICALLY."

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CiES stocks arms in half-inch increments and can quickly produce other working variations. A CNC rod bender in the shop whips out new arms in seconds. Senders are built from standard parts. The unit is attached with a basic bolt pattern housing orientation of 12, 3, 6, and 9 o'clock used almost universally in aircraft.

When an order comes in for a configuration previously produced, it is built to order from parts in stock. For new orders, customers send their current sender and an illustrated parts catalog image or photo. CiES documents the new configuration and submits it to the FAA for the next STC update.

"It's straightforward for us to handle experimental aircraft requests since they typically were designed to use a resistive sender," Scott said. "Simply making one of the stock configurations is relatively straightforward."

CiES is currently supporting Cessna twin-engine aircraft that use the penny cap capacitive system and replacing them with CiES sensors that are more straightforward, reliable, and accurate.

LOCATION AND INSTALLATION

"TELL ME WHERE it needs to go, and we can typically accommodate that," Scott said.

The CiES unit will fit into any aircraft and can be mounted on the top, side, bottom, or interior of a fuel tank. For example, units for Beechcraft Bonanzas and Barons are installed on top while units for Wacos bolt to the bottom. Piper Malibu and Cessna TTx aircraft have them mounted on the inside of the tank. A rib side mounting is suggested for new experimental aircraft since it centers the unit on the tank and makes it less pitch sensitive.

The number of senders in any given tank depends upon its size and shape. A Baron with its long tanks has three senders. High-wing aircraft with straight wings, such as a Cessna 210, have only one sender per tank whereas a low-wing Bonanza with its higher dihedral for stability has two senders. Cirrus SF50 jet aircraft have three per tank, and other aircraft with even larger tanks have four.

Installation takes four hours per sensor on average. Three wires for power, ground, and signal are required since the active sensor requires electricity to operate the microprocessor.

LEGACY LOOK

"YOU WOULD SUSPECT that new fuel sender technology should look robotic or something," Scott said. "To make it look like the legacy float sender without any of the legacy issues is a little deceptive in some ways, but it's worked fantastically."

The mean time to failure of a CiES unit is more than 90,000 hours.

CiES initially suspected that promoting the benefits of its new system would be a hard sell since it looked very much like the old senders. In the beginning, this proved to be true.

"Now that we have been out there and people have been talking about us, it's almost a religious experience for them having accurate fuel level in a GA aircraft, and they spread the word," Scott said. "It doesn't matter to anybody what the technology looks like inside doing those things. All that matters is that you get good information in the cockpit."

FIRST RV-10 INSTALLATION

WHEN LAYNE BOGULAS, EAA 868068, finished building his RV-10 in 2016, it had a conventional fuel sending unit. When he decided to install the CiES system, in addition to removing the wing tanks and installing the senders, the unit needed to be calibrated and mapped since his was the first RV-10 installation.

Due to the dihedral of the RV-10 wing, one fuel sender is on the bottom of the tank and one at the top. Since the top float can only go so high, the sender starts measuring after 7 gallons of fuel has been used and measures from 30 gallons down to zero. The system integrates with his Garmin G3 avionics, and he has flown a couple of hundred hours with it.

"When you don't have to second-guess things, it makes it easy not to worry about it," Layne said. "If it says you're 10 gallons down, you're 10 gallons down. If it says 9.8, it's 9.8. You don't get erratic fuel sensing when the plane jostles around in rough weather. It's spot on all the time."

OTHER COMPONENTS

IN ADDITION TO accurate fuel level technology, CiES is working on other fuel system components. It has been working with RDD Enterprises in Redmond, Oregon, for automated tank switching for its LX7, which is a modification of the Lancair IV-P with similar speed capacities but more docile handling characteristics and an airframe parachute.

Accurate fuel quantity technology makes intelligently automated tank switching feasible.

"Now that you have a fuel level system that's reliable, you can start automating processes that used to rely on the pilot," Scott said.

This system can assist the pilot in automating the selection of a fuel tank, keeping, for example, two LX7 90-gallon wing tanks within 1 gallon of each other throughout a flight.

CiES is also working on a prototype app that reports a digital fuel readout to your cellphone.

"You can sit in the FBO and watch your airplane be fueled to the level that you specified and see it visually happening in front of you," Scott said.

It's been more than half a dozen years since Scott started on a quest to solve this age-old aviation problem, and his persistence has finally paid off.

"One of the things people warned us about when we started is that you're going to get your pants sued off, as pilots will find a way to run out of gas," he said. "Thankfully, with over 29,000 senders in the field right now, we haven't had, to date, a single pilot starve an engine or run out of fuel with our system onboard."

Beth E. Stanton, EAA 1076326, is a recovering competition aerobatic pilot who is now working on ratings to become a CFI. She can be reached at *bethestanton@gmail.com*.