During uneventful VFR cross-country flights, I tend to daydream about modifications I plan to make to my airplane. During choppy days in the clouds I lust for an autopilot, other days it's a multifunction display to clean up the panel space. On the longer flights, it may be more padding for my posterior. On night flights, I may vow to add additional lights to better illuminate my charts. There is one mod, however, that always ends up at the top of my list: fuel.

BY ART TREFF

FUEL'S THE TOOL

EXTENDED-RANGE TANKS CAN ADD VERSATILITY TO YOUR AIRPLANE

AN INCREASE IN FUEL CAPACITY is the one modification that can deliver gains in three categories: speed, safety, and economy. Want to add more than 30 knots to your airplane? It may be possible just by adding fuel. Where else can you achieve such a gain in performance?

The riddle is solved with simple arithmetic: Two planes of identical configuration leave on an 835 nm trip. Both ships cruise at a true airspeed of 185 knots at 8,000 feet, burning 10 gph. In the climb they both burn 14 gph. The only difference between the two aircraft is fuel quantity. Aircraft A carries four hours of fuel; Aircraft B has five hours of flight without reserve.

Aircraft A bids the wingman adieu and stops for fuel after 3.5 hours of travel. Aircraft B soldiers on, not needing fuel. Ship A arrives at the destination an hour later with an average speed 30 knots slower due to the fuel stop. Losing the altitude and pattern work eat up 10 minutes. Additional messing with fuel, money, and bathroom costs 38 minutes. Taxiing out, run-up, and climb to altitude burn up another 22 minutes before Ship A is back up to 185 knots. Total time penalty for the fuel stop is 60 minutes, which makes the average groundspeed for the trip 151 knots.

It warms my heart to know that I carry sufficient fuel to soldier on to greener pastures with ample reserves.

Ship B did not stop for fuel by virtue of the larger fuel supply, and landed with the required 30-minute fuel reserve. Average groundspeed for the trip: 185 knots.

For this trip, Aircraft B was faster than A by a whopping 34 knots. Talk about a speed mod!

Bigger tanks can also save money. It is important to note that, in the example above, Aircraft A had to burn an additional 3 gallons during the climb-out after the pit stop. Every time you land only to add fuel, you will spend a few gallons on the climb back to altitude. Not every airplane or every pilot flies to make long trips, however. But larger fuel tanks also mean you can fill up at a pump with low prices and bypass the others charging higher rates.

What about safety? When flying in marginal weather, you may have equipped your instrument panel to rival the flight deck of a Boeing 777, but if you don't carry enough gas to keep the big fan up front spinning, you may as well be asking a Ouija board to direct your safe passage homeward. Fuel is the big equalizer. It's the silver bullet in a pilot's holster when Mother Nature goes postal. Yes, when I'm flying along, basking in the sunny skies above an ugly overcast layer and Satan is wreaking havoc below (low ceilings, rain, wind), it warms my heart to know that I carry sufficient

fuel to soldier on to greener pastures with ample reserves.

Once I was grounded for want of an extra hour of fuel that would have been necessary to comfortably fly IFR. I had planned a flight from central Florida to western North Carolina. A summer high-pressure system was keeping morning visibilities in the center of my intended route to below 1 mile in fog and haze. My departure and destination airports were showing marginal VFR with an improving forecast.

With normal prevailing winds, this trip would take two hours, 40 minutes, which leaves suitable IFR reserves if my alternate is not too distant. On this particular day, the wind was against me, which added 30 minutes to the trip, necessitating a fuel stop to stay legal and safe. The fuel stop would have to be in the middle of a low-IFR area that had ceilings indefinite and visibilities of ½ mile and less. Additionally, the fogbound area was large enough that if I missed the approach at the fuel stop, I would not have enough fuel to reach a safe alternate.

And so I sat it out. Unless the visibilities improved enough to where I could find a suitable alternate to my fuel stop, an extra hour of gas would have allowed me to reach my destination with enough time in the tanks for a legal alternate.

FINDING AN HOUR

My mind made up, I decided to look into extended range tanks for my RV-8. My search turned up Hotel Whiskey Aviation (HWA) tanks that would add 9 gallons. These are tubular tanks that begin at the outboard side of the main fuel tanks, and pass through wing rib lightening holes and terminate in the wingtip. The filler neck is accessed via a door in the wingtip.

Aux fuel in the tubular tanks is fed via a Facet solid-state pump to a fitting on the main fuel tank at the outboard rib. This pump also functions as a shutoff, guarding against siphon and backflow.

This product configuration appeals to me for many reasons. First, the kit can be retrofit to completed RV wing and fuel tank assemblies without altering the stock fuel system in any way. Second, the location of the aux tanks does not shift the center of gravity. The 13-pound 6-ounce modification, which does not need additional testing to satisfy the FAA, adds an hour of cruise flight. Finally, the system and its attachments have been tested to 9g, with the testing monitored by an FAA designated engineering representative (DER).

HWA's beginning is a typical homebuilding story: a real-world need fueled an idea, which led to a design that was so successful that it blossomed into a product. A few years ago, two professional pilots, Jeff Hanson and Chuck Wilson (the "hotel" and "whiskey"), teamed to build a couple of RV-4s. Both were fighter pilots who appreciated the -4's handling and aerobatic capability.

With the tank bolted into a simulated wing setup, the fuel tank was loaded with sandbags to a 9g load, at which point there was no deflection of the tank or the mounts.

The need for extended range tanks became obvious on a long cross-country flight, a two-ship hop from the Dallas area to Las Cruces, New Mexico, in the newly built airplanes. The wind gods were not kind to the pair, so they stopped for fuel once on the way out and twice on the way home. It became clear the ship was a capable cross-country machine whose utility was being hindered by its 32-gallon fuel capacity.

Chuck and Jeff had two finished aircraft on their hands, so a primary design criterion was that the aux fuel system had to be installed without removing any wing panels or ruining the paint. Additionally, they wanted to add at least one hour of fuel. Tip tanks were already on the market, but the pair did not like the idea of hanging that fuel weight off the existing No. 6 screws in the wingtips.

The tubular tank concept evolved as soon as the designers realized how much unused space lay in the wing rib lightening holes. Grumman American had used tubular wing spars that also contained fuel for the Yankee/Cheetah/Tiger lines of single-engine aircraft, so the concept was flight-proven.

The design is simple: seal the ends of an aluminum tube and mount it within the wing rib holes. A fuel line passes from the aux tank inboard, behind the main fuel tanks, and is plumbed into the ship's main tank through an AN fitting and bung riveted to the inboard main tank rib. A simple cockpit-actuated ball valve controls the gravity-fed fuel flow out of the aux tank into the main. The tank is secured to wing ribs at the inboard station by a stainless steel band clamp supported by four aluminum angles, which are bolted to the ribs. The outer aux tank station is bolted to the wing rib by welded attach brackets. *Voilà*: no modification to the stock Van's fuel system is necessary.

Jeff contacted a retired DER from the Dallas FSDO to look over the pair's proposed tank design. The DER scrutinized the drawings and material choices. He went on to help Jeff prepare a test loading procedure and fixture. With the tank bolted into a simulated wing setup, the fuel tank was loaded with sandbags to a 9g load, at which point there was no deflection of the tank or the mounts. Testing was not continued to ultimate failure because the wing will fail above 9g. After all this was complete, the DER provided a letter certifying that the tank design was airworthy and safe.

Flight tests were then performed in the various configurations to check for unusual handling or failure to feed fuel. The aux tanks were tested for flow up to 12,500 feet with no gravity feeding problems in normal

Left: The complete RV-8 kit contains all of the parts needed for installation, including box tanks at the outboard end. The solid-state fuel pump (below) also works as a check valve.

Right: Inboard view of the test mount used to verify the design and installation.

Far Right: The inboard mounting uses four aluminum angles bolted to the ribs and then attached to the tank with a band clamp.

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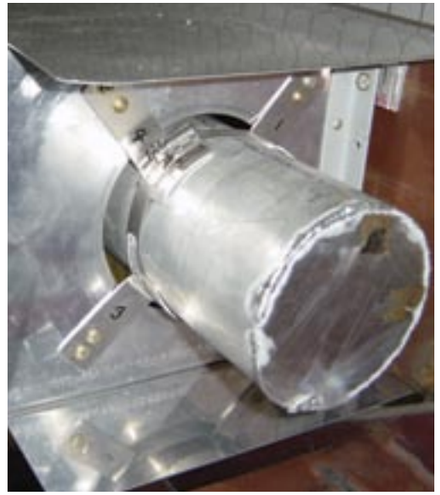

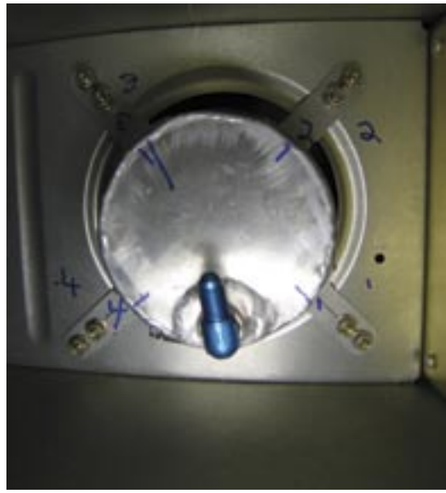

Left: The assembly was tested to 9g without deflection, showing the wing would fail before the tank assembly

cruise flight. The acid test for the new system was to check handling, with one wing totally dry and the other aux and main tanks full. Despite this lateral imbalance, no adverse flight behavior was discovered, other than a slightly heavy left stick.

Once all testing was complete, the Dallas FSDO was contacted for an opinion as to whether the new aux tanks would be considered a major modification, requiring 25 additional flight test hours to be flown. The answer was no, because the kit was designed and tested thoroughly, the center of gravity does not shift appreciably, and the original fuel system isn't altered. If the tanks were installed in an unfinished plane, this would not enter the equation at all.

A COMPANY IS BORN

As is the norm in experimental aviation, the word spread that a pair of RV-4 builders added fuel tanks to the inside of a finished wing. Other RV builders contacted Jeff and Chuck, and Hotel Whiskey was born. The pair started tooling up to sell fuel tank kits. Van's Aircraft has no official position on the company's aux tanks; however, Van's did display the RV-4 tanks in its booth at Sun 'n Fun 2003 and published an article on them in its builder newsletter, *The RVator*. In short order, Hotel Whiskey had multiple orders on its hands.

The wing configuration on the -4 and -6 are identical, so making the -4 kits available for the RV-6 was easy, but the RV-7 and -8 required more design work if they were going to maintain their initial criteria of one hour of additional fuel and retrofittable to a painted, flying aircraft.

In the -7 and -8 wings, the main fuel tanks extend farther outboard than in the earlier designs, which shortens the potential length of the fuel tube, making the Holy Grail of one hour of fuel out of reach. Jeff and Chuck added a box shape to the outboard side of the tubular tank, to reside within the wingtip. One hurdle down, one to go.

The newer RV wings secure the leading edge fuel tanks to the spar via Z-brackets and AN bolts. The presence of these brackets makes passing the aluminum fuel line from the ER tanks behind the main tanks impossible, so a new approach evolved. A solid-state fuel pump was added to pump fuel from the ER tank to the plane's main tank.

Tapping into the main supply is not something the HWA guys took lightly. They had to guard against siphoning fuel from the main tank as well as fuel traveling downstream from the ER tanks. The pump they include in their kit is a Facet solid-state unit, which will move 19 gallons per hour, and it functions as a valve when not in operation. The durability of this product has been proven in the automotive market. Its materials are compatible with auto fuel as well as 100LL avgas. This pumped-fuel approach has garnered customer accolades, so RV-4 and -6 customers can ask for the fuel pump as an alternative to the earlier gravity-fed ER tank design.

Flight operation with the fuel pump version is dirt simple. The engine is fed from the main tanks. When sufficient fuel has been drained from each main tank, the ER tank pumps are switched on from the cockpit. Sixteen minutes later, the ER tanks are empty and each main tank has an additional 4.5 gallons (7.5 gallons in the RV-10 version). If the mains won't hold the fuel being pumped in, it will go overboard via the fuel vents. A timer switches on

The inboard end of the installed tank, ready to be plumbed into the main tank.

The main tank is reinstalled on the wing, with the aux tank fuel line visible on the right.

a warning LED when the pump has been on for more than 20 minutes, prompting the pilot to turn it off.

I WENT FOR IT

With my RV-8 still under construction, I had already concluded the stock 42 gallons would not suffice on some longer trips. I decided to install the HWA tanks during the build. The experience has been great.

My box arrived with the cardboard badly damaged, but my angst gave way to glee when I opened the crate: The kit was expertly packed in wood and nothing was damaged. The directions are legible, well thought out, and supplemented with color photographs of crucial assembly steps. Tank mounts, hydraulic fittings, hoses, tubing, hardware, and sheet metal cut to size (and de-burred) are all included. Wire and terminal ends, pre-printed placards, and even a small sheet of screening to bond into the vent lines are part of the kit.

"Chuck and I are builders ourselves. We hate having to stop working on a project to run out for something that's not included in the kit. For that reason, we put things in our kits like the vent screen, placards, and terminal ends," Jeff says.

Installation is simple. Main tanks are removed and an NPT bung is riveted and pro-sealed in the outboard tank rib using sealed blind rivets. Once the bung sealing was dry, I leak checked the installation with 2PSI shop air and squirted soapy water on the newly installed fitting. The fuel tank bung and sealed blind rivet kits are available separately if you want to install the bung now and keep your options open for the future.

With the wingtip removed, the tubular tank is passed through the rib holes into position for drilling. The fuel pump is then located on the rib adjacent to the main fuel tank, drilled, and installed. The ER tank can then be bolted in place along with the fuel pump. Wiring a ground and a power wire is next. I could have snaked the power into the electrical conduit that is already in place, but I found it easier to drill 1/4-inch holes in the wing ribs and install snap bushings to run the wire to the wing root.

The final step to the ER tank installation is attaching the Aeroquip hose (provided) between the main tank and the Facet pump. The hose was the perfect length to allow the main tank to be swung back into position and reinstalled easily.

I did not want to risk any surprises when I bolted on my wings, so I filled the ER tanks with mineral spirits and applied voltage to the aux pumps. The system neatly transferred the fluid into the main tanks without leaks. This step also functioned to flush any debris from the fuel system.

With the metal work out of the way, I installed two switches into my left switch panel. I installed the pump warning LED above the applicable switch. Power was brought from the main bus, and I hooked up the electronic timer mechanism, mounting the box easily under my switch armrest.

The final step in the ER tank installation is to cut a 4-inch access door in the wingtip. The process is thoroughly covered in Hotel Whiskey's instruction book, with the color photos taking all the guesswork out of the process. If you cut the door carefully, you can keep the cutout as the door, and rivet the doubler (included in the kit) underneath it. A hinge and push-button Camloc latch are installed last. On the flightline, a push of the flush-mounted door button reveals the fuel cap underneath with plenty of clearance for the fuel truck hose. Installation takes about 20 hours.

My aftermarket sheared-style wingtips are from Massey Aircraft. HWA has measured the sheared tips on the RV-7 kit, and the ER tanks' tip box will fit. Jeff and Chuck installed the first RV-8 tanks in Danny King's *Beautiful Doll*, which has the older stock Hoerner style wingtips, and the ER tanks fit easily within them as well.

I am happy with my decision to install long-range tanks in my airplane. More fuel equals more speed, a greater safety margin, and fuel economy on long trips. This kit is a joy to install. Additionally, Chuck and Jeff will install the kit on your RV at their facility if you wish.

After completing the development of the tanks, Chuck and Jeff retraced their steps to New Mexico. They did not have to stop for fuel outbound or on the way home. They were elated with the convenience of not having to stop, but the showstopper was how much they thoroughly enjoyed the relaxation of not sweating out the gas situation on a long trip. In some ways, that could be the best addition to an RV yet.

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