ON NOT RUNNING OUT OF FUEL

BY

ALAN MALONE

I have read that the most popular cause of engine failure in flight is running out of gas. That seems strange, since the law requires us to carry at least an extra half-hour of fuel when we go up flying. Most people carry more than that, or say they do. I talk to lots of pilots and flight instructors, and I have yet to hear anyone say he thinks it's okay to arrive with as little as half an hour of fuel in his tanks.

So how do people manage to run dry? I've been looking into my own experience, as well as talking with some other pilots, and I've come to the conclusion that running out of gas is a pretty easy thing to do. Even people who think they're carrying an extra thirty minutes can do it without even breathing hard.

The way it's supposed to happen is that you carry enough gas to start the engine and warm up a couple of minutes while you turn on the radios, tune frequencies, get the ATIS, call ground or clearance delivery, and taxi out to the active runway, where you perform some pre-takeoff checks of your systems. Then you carry enough to take off and climb to whatever altitude you want to use. Then you carry enough to cruise to wherever you want to start your descent. Then you carry enough to descend, land, taxi in, and park. If you run out of gas at this point, nobody will probably ever know, unless you ask the line guys to top off the tanks and it takes more than the putative useful capacity.

Oh yeah. There's one more item. You should carry enough to have at least thirty minutes of reserve in the daytime and forty-five at night. That's predicated on cruising fuel consumption. I suppose that means however much your POH is going to say you're burning, going whatever speed you've put on your flight plan. If you're flying IFR, you're supposed to have at least forty-five minutes of reserve fuel whenever you land.

This is not exactly rocket science. You do a relatively simple calculation of how much you're going to need, then you stick that amount into the tanks, plus maybe some extra for the kids, and that's how much you carry. So how come so many of us find ourselves taking off in airplanes and landing in gliders?

I think there are several reasons why this fate can befall us. The first is that sometimes we don't know how much fuel we're carrying. One of my FAA inspector supervisors, Amy Pilkinton, once said that the only time you know for sure how much fuel you have in your tanks is when they're plumb full and when they're plumb empty. If you're carrying partial fuel, as we sometimes do, you're probably going by some kind of estimate, using the WAG method. You may have been taught by your instructor that the only reliable method of checking fuel quantity is to "stick it," that is, insert a stick into the tank and then observe how far up the stick it is wet with fuel.

Let me tell you a little story about sticking the fuel. I was once giving a private practical test to a gentleman, and he was, as part of the test, showing me how well he could preflight the airplane, a Cessna 152. The plane was parked in the grass, right off the edge of a concrete ramp.

First, following his checklist, he turned on the master switch and observed that the gauges read less than half. As I remember it, they were down around the quarter-full mark. He told me these readings were unreliable, and that he'd have to inspect the tanks visually. That was right. That was good. This guy knew something about fuel, I thought. He climbed up and took off the gas caps, confirming that we had less than full tanks. He stuck his finger into the tank and discovered that he couldn't touch the fuel. The "finger-in-the-tank" trick is useful in this type of airplane, since you can generally count on less than an hour out of full tanks if you can touch the gas, and more than an hour out if you can't.

Then he did another intelligent thing. He grabbed hold of the wing strut to pull the plane off the grass and onto the ramp. This would level the plane, he explained, so that being tipped over a little bit wouldn't make it seem as if there were more in one tank and less in the other. I was even more impressed. I told him I'd try to find a stick while he was moving the Cessna.

I got a stick out of another 152 that was parked nearby, and he stuck the tanks in the level airplane. According to the pilot, the stick indicated that we had somewhere between a half and three-quarters in the tanks. He asked me how long we'd be up, and I said somewhere between an hour and an hour and a half. He opined that we had enough gas, and we strapped in.

As he ran his checklist, I noticed that the gauges were indicating about a quarter. That should come up some when he started the engine. Usually, when the electrons start to flow, the fuel gauges in Cessnas come up a bit. He started the engine. They didn't.

I started to fantasize that I was sitting across the table from one of those FAA types, trying to explain how we managed to run out of fuel on a private practical test. I imagined myself telling the inspector about how we did all these correct things to determine how much fuel we had aboard. Then I imagined how he'd be going behind me and showing me where I had gone wrong: "Ya stuck the tanks, huh? Was the stick marked for a 152? Did the applicant know to put his thumb on the stick, right where the top of the gas tank was, a little bit down from the top of the filler? **Did anyone check the fueling history of the airplane?**

Humm. I reached around and fished the little clipboard out of the back, the one with the time sheet that tells how long everyone flew the bird. The last two flights were about 1.3 hours and 1.2, something like that. About enough, with takeoffs and landings and taxiing and running up, to bring the fuel supply down below a half, to bring it way down below where we needed it to be, to have our healthy reserve.

"Would it offend you if I asked you to put five gallons in each side?" I asked. He was, after all, pilot-in-command. "I'm noticing that the tanks are reading less than a half, and that the gauges didn't come up when you started the engine. The time sheet shows that it's probably got 2.5 out of full tanks, and I doubt that this little bird holds four hours of fuel. If we add the ten, then we'll know we've got at least enough to make this flight safely."

He looked at me like I was crazy. He had stuck the tanks, hadn't he? But what the heck, I was the examiner, and he was not about to get into a disagreement with me, right in the middle of the test. We taxied around and asked the guy to put five in each side. The indicators came up to where they should have been, and we went on our merry way.

The next day I went back and took another look at the stick. It wasn't marked for the tanks of a Cessna 152. It had four bands painted on it, indicating the quantity of fuel for a different model, a plane with differently shaped tanks than we had had. Murphy's Law had almost had us doing a dead-stick landing on the Interstate 10. Even the vaunted "stick the tanks on a level plane" method was not infallible.

My conclusion, from this almost-sorry affair, was that we should use as much information as possible, and put together the best estimate of how much go-juice we have, in the event that we don't top off before departure. We shouldn't make assumptions, and we should pay heed to the method that indicates the *least* amount of fuel. When in doubt, we should put some in.

If partial fuel is carried, the quantity is questionable. Even if we ask the folks working the line to top us off, sometimes they don't do it. Often they are anxious not to get chewed out for overflowing the fillers and getting ugly gas stains all over our nice shiny wing. Sometimes, therefore, they carefully fill the tanks until they look pretty full, but they may actually be as much as a few gallons shy of their total capacity. Remember, gas tanks, because they must fit inside the wings, must be very broad and flat. If the top of the fuel is just a little bit down from the very top of the tank, you may be several gallons short. I often find, when I calculate my gas mileage, that my fuel consumption is greater than usual when I fuel the airplane myself. I suspect that this is because I would rather get a little gas on top of the wing than underfill the tanks. Could it be that the last guy who serviced the bird was a little bit short? That shortage would show up as a little extra fuel when I use my overflow method. This could very well be why the calculated fuel flow would look like extra gallons per hour. It's happened often enough to make me wonder.

Assuming that we know how much fuel we have in the tanks, the next question is whether or not that's the amount we need. When we do these famous "flight plans," where we fill in little forms with information about "check points," we crunch a bunch of numbers, trying to arrive at an amount of fuel that will be required to make the flight successfully.

Number-crunching, like the sticking of the tank, doesn't always produce reliable results. The numbers come from the putative true airspeed of the airplane and the speed and direction of the wind. Combined with the rate of fuel consumption that should produce the true airspeed we're using, we should be able to go through some involved, but fairly simple, calculations to determine whether we're likely to be able to make the flight non-stop. Two of the numbers that are the basis of our calculations, however, are a bit uncertain. One, as we have seen, is how much fuel we're carrying. The other is the wind.

Even if you gas up the bird yourself and assure yourself that you do, indeed, have full tanks, you still have the uncertainty of the wind to contend with. Let's say you have an airplane that cruises at one hundred knots and you have a winds-aloft forecast of ten knots. The wind is expected to be changing your ground speed up to ten percent. What's worse, the wind is only given to the nearest ten knots in the first place, so there's another plus or minus five percent uncertainty in that figure, even assuming that the weather men are guessing right and that the wind is going to be blowing with a constant velocity.*

To cut to the chase, there's an uncertainty of your ground speed of up to ten, or even fifteen percent, assuming that you're flying in a relatively slow airplane. Most pilots base their calculations on the best numbers the meteorologists can come up with and plan their fuel accordingly. What if they're wrong? What if they end up covering ground ten percent slower than they had figured?

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There are two questions to deal with in this case. Do you know that your speed is ten percent slow, and what are you going to do about it?

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One good practice I encourage all pilots to adhere to is to take the entire mileage of the trip and to divide that by the amount of fuel they intend to carry, in hours, not counting the reserve fuel. Performing this division, the answer will be the minimum *average* ground speed that will result in an arrival at the destination with the desired reserve.

For example, if you intend to go 280 nautical miles, the airplane carries four hours of gas, and you want to land with an hour's worth of reserve, you would divide 280 by three (that is, your total fuel minus the reserve). You would find 94 knots to be the minimum *average* ground speed you're going to need. After you settle down to cruising, you can check your GPS navigator to see how close your ground speed is to that number. If the ground speed is reading out numbers between 108 and 115, you're fat. You know you have enough gas to make it, if the wind velocity doesn't change too much. If the GPS is reading somewhere between 85 and 98, you're awfully close to the line, and you might want to think about making an intermediate stop. Remember, it's the ***average*** speed you're concerned with. That includes the slow speed you'll be making during your climb to cruising altitude, as well as any deviations ATC may require. Bouncy air will also reduce the rate at which you are covering ground. It may be a good idea to keep a running tally of your *total* distance divided by *total* time, as you reach successive checkpoints. This practice will yield an increasingly high number for your *average ground speed*, as the cruising speed increasingly dominates the slower climb speed.

In case this is not ringing any bells with you, let's assume that this 100 knot airplane can climb at 500 feet per minute, and that you intend to cruise at 5000 feet. The climb will be made at 70 knots, for the sake of this discussion. It will take ten minutes to reach cruising altitude, and the flight will have covered about 11.6 miles horizontally, during the climb. When the aircraft levels off at five grand, its average ground speed will be 70 knots, assuming that wind is not a factor.

The airplane then cruises for an hour at its 100 knot cruising speed. During this time it covers 100 miles, bringing the airplane 111.6 miles from its point of departure. This has taken one hour and ten minutes, for an average ground speed of

95.7 knots. This is the largest hour-increase you are going to see, from 70 to 95.7 knots.

You now cruise another hour at 100 knots. This takes you 211.6 miles from home plate, during a time of two hours and 10 minutes, for an average ground speed of 97.7 knots.

Following a third hour of cruising, you have come to a point 311.6 miles from home in 3 hours and 10 minutes, for an average ground speed of 98.4 knots.

As can be seen, the longer you cruise, the higher is your ***average ground speed***, since the slower climb speed becomes a smaller and smaller part of the overall picture. You approach an average speed of 100 knots, but never quite get there, since you still have to factor in that first ten minutes of covering ground at 70 knots.

Now it's time to descend. Logic tells us that what we lose in climb, we gain back in descent. This is not correct. I typically descend at 500 feet per minute, using a cruise power setting of around 2500 RPM, in my little Cessna. This brings the speed up maybe ten knots. Assuming that I was able to climb at 500 FPM, a dubious assumption in this type of airplane, my climb time and descent time should be roughly similar. The climb speed was 70, remember, 30 knots less than cruise speed. Because I am going fast as I descend, the drag on the airframe is much greater on the way down, and I do not *gain* 30 knots over my cruise speed. At most, the increase is usually about ten knots. I also sometimes have to slow down a little bit because of turbulence as I descend, and this eats up even more time and gas.

Alas, the benefits of descending do not balance the sacrifices of climbing, and we come out losers. Physicists have a name for this phenomenon: the Second Law of Thermodynamics. If you want to stay safe, do not figure your fuel so closely that you need to save a few drops in your descent. If you're that close to the line, you are in trouble. Just a little bit of increase in headwind as you come down can turn you into a glider pilot.

Lastly, what if you're not making a nice, organized cross-country flight, with all of the little boxes filled in, the charts marked, and the necessary fuel carefully calculated? What if you're just going out with your buddy to bat around the area for a little while? What if you're going to see who can do the best three out of five chandelles, then buzz over to Shreveport for a hamburger? What the heck, I hear the waitress is cuter over in Monroe. Let's go there. I think it's over in that direction someplace. Just take up a heading and we'll find the railroad tracks in a little while… This kind of flying is sometimes done with little regard for how much time has elapsed. Maybe the pilot has not consciously thought of an "on the ground" time. Or, even worse, maybe each pilot has assumed that the other one is keeping track of the go-juice!

To summarize, there are a number of factors that make the amount of fuel we need an uncertain number. The amount we *have* can also be a little bit iffy. To defend ourselves from these uncertainties, we should carry along more fuel than we think we'll need. The amount of uncertainty is sometimes more than we expect, and how much fuel is prudent is something each pilot must decide for himself.

Before you undertake a flight, you should probably compute the maximum amount of fuel you think you'll need, under the worst of anticipated conditions, then add another hour of fuel, at cruising consumption. Then put your tongue in your cheek, cross your fingers, knock wood, and make sure that you keep track of what time you're due back on *terra firma*. The uncertainty demon is always out there looking for a way to run you out of gas. Don't give him an easy target.

*With modern whizbang computers, these days, we get interpolated figures in the winds aloft forecasts. I almost dropped my uppers the first time a briefer told me that the forecast wind at my altitude was going to be 028 degrees at 16 knots. Just remember, those figures are based on a manipulation of the numbers we used to get, which were only precise to within +/- 10 degrees and +/- 10 knots.