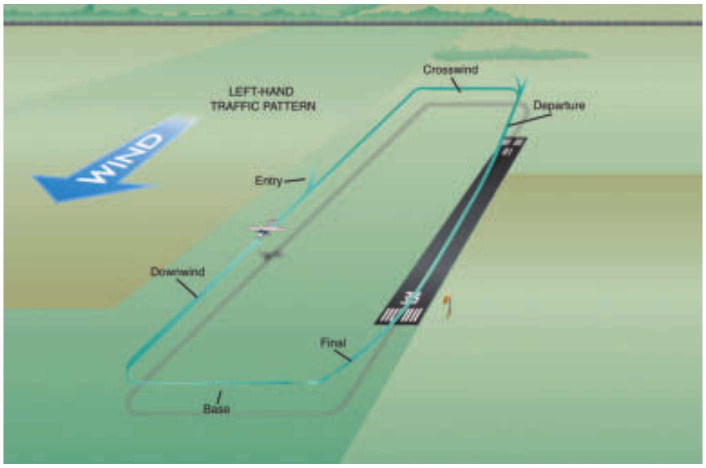
The Downwind Turn

One more time

BY CHARLIE PRECOURT, EAA BOARD OF DIRECTORS, SAFETY COMMITTEE CHAIRMAN

IN OUR MAY ISSUE, Dave Morss discussed low-altitude emergencies, with a focus on the NTSB's data that show most E-AB fatalities involve engine or flight control problems that become too much to handle near the ground. He examined engine failures on takeoff and the conditions that might enable a turn downwind, back to the runway. Dave commented, "Maneuvering near the ground is very different…ground rush can be very disorienting, so even if a turn can be executed 'mathematically,' the chances for error are high." Given the inherent risks, further examination of the "downwind turn" is worthwhile. I give credit for the genesis of this article to EAA member Garrett Van Wyk, EAA 46468, who wrote us about his analyses of many accidents that occurred during downwind turns near the ground.

As the term "downwind" implies, our concern here is the effect of the wind on the aircraft's performance as it makes the turn. In steady air with constant wind velocity, while performing a "normal" turn, the aircraft will experience no aerodynamic effect from the wind, only a navigation effect. We set bank angle, pitch to hold level altitude, power to compensate for the increased drag from the *g*'s we pull in the turn, and perform consecutive 360s without noticing the wind we're flying in—as long as we don't care where we are over the earth, and allow ourselves to drift downwind. In this normal turn, our indicated airspeed and altitude are constant even though we know our groundspeed increases significantly as we turn downwind.



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Sounds pretty simple. But numerous accidents at low altitude suggest something must be going wrong with the assumptions of my normal turn. Some claim to see loss of indicated airspeed in the downwind turn, which can lead to bad things—altitude loss, stall, and loss of control. But airspeed doesn't drop in my normal turn.

Applying physics to the analysis reveals some interesting things we don't normally discuss in basic aerodynamics. An aircraft's *total* energy in equilibrium flight must remain constant unless something is added (more power for example) or subtracted (drag devices for example). Total energy combines speed and altitude (kinetic energy and potential energy) relative to the ground (motionless on the ground equals zero energy).

Airborne at 1,000 feet and 120 knots into a 20-knot wind is 100 knots relative to the ground. Turn downwind, hold 1,000 feet, and our groundspeed is 140 knots. The altitude component of total energy didn't change but the speed component did. With power fixed in a normal turn to hold indicated speed, where does the extra energy come from to accelerate the aircraft? Obviously it is imparted by the wind during the turn, *if* there is enough time in the turn for the wind to act upon it.

Think about your parked aircraft not tied down on the ground, and a 20-knot tailwind comes along. It would start pushing the aircraft. The longer the wind endures, the faster the plane goes (theoretically, with no wheel friction it eventually matches wind speed). A lighter aircraft will accelerate more quickly than a heavier one, an inertia effect. Similarly, in our normal turn in flight the wind had enough "pushing" time to change groundspeed with no effect on indicated speed.

Running the calculations for mass and acceleration (I'll spare you the equations here) for a 2,000-pound aircraft in a 45-degree bank, 100 KIAS, you find a 180-degree turn takes about 16 seconds. If a 20-knot wind has 16 seconds to accelerate the 2,000-pound aircraft from 100 knots upwind to 140 knots downwind, the equivalent surface area (that the wind pushes on) needs to be about 200 square feet.

That's reasonable for aircraft this size when you consider the "sail" the wind is pushing is the fuselage, wing, and the tail surfaces facing into the wind. And our traditional aerodynamic understanding of equilibrium flight squares with this result: The aircraft doesn't care what the air mass is doing. So if we are having problems at low altitude, we must not be flying a normal turn, and indeed there are a number of things that cause that to happen.

The first is a change in our reference frame for flight control. In the normal turn, we use the old "composite" cross-check—outside, the horizon for attitude; inside, the airspeed, altimeter, and slip indicator for control feedback. But at low altitude we are compelled to fly to particular points on the ground. This distracts us from the composite cross-check. You "feel" groundspeed close to the ground and erroneously respond to it (instead of to indicated speed), instinctively raising the nose to slow down or pulling power, either causing an undesired drop in indicated speed.

The other reality we face is wind shear. This sudden change in wind speed or direction instantaneously changes our indicated speed. Instantaneous changes from head- to tailwind don't allow enough time for the wind to accelerate the aircraft (per the physics discussion above) and will result in a drop of indicated speed. So wind shear, rather than steady wind, is the killer. Combine the groundspeed change sensation with wind shear affects and you have a handful.

The higher groundspeed downwind also robs you of time to clear obstacles, both because climb *angles* will be less (even though climb *rate* is the same) and turning radius will be higher, than upwind. You can get into a spot with obstacles downwind (can't turn fast enough or climb quickly enough) that would not have been a problem upwind.

The crosswind part of our downwind turn is another issue. The sideways drift makes us feel an illusion of slip, even though the ball is centered. Instinctively we want to feed in rudder, but this will cause further increase in bank and a loss of altitude. If you react with opposite aileron to correct the bank, and nose-up elevator to stop the descent, you have a cross-control, low-altitude spin entry!

The bottom line is that a low-level downwind turn can be hazardous. Another reason we highly recommend your test flights be on days with light winds. If you have to turn downwind at low altitude, do it with a plan in mind, and remember a disciplined composite cross-check will keep you out of trouble.

This month we also pause to remember our founder, Paul Poberezny. He has done so much for EAA and all of us who fly. He also was the inspiration behind this monthly article, and the renewed emphasis EAA has taken to provide our membership with the tools to be safer. Godspeed, Paul!