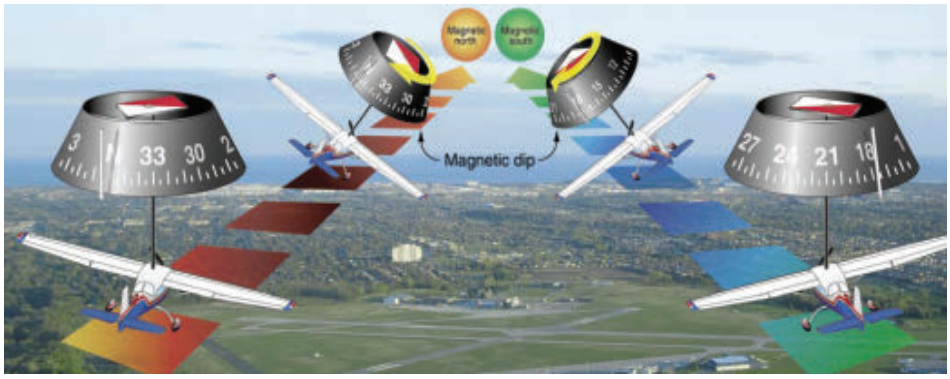
Partial Panel Compass Turns

A worst-case scenario

BY ROBERT ROSSIER

IT WAS ONE OF those scenarios we train for, but seldom occurs—a vacuum pump failure that left the pilot in a partial panel situation in IMC conditions. Certainly not a situation for a VFR pilot to attempt to manage, but for the recently rated instrument pilot who was a student of mine, it was well within his capabilities. Had the airplane been so equipped, the easy out would have been to use the heading information provided by the GPS. Unfortunately, the aging trainer had no GPS. No doubt, ATC would simply provide vectors for a straight-in approach to Greeley/Weld County Airport—and shortly thereafter, the ordeal would be over. But that's not the way it was going down. Not by a long shot.

"Roger, Five Alpha Delta, understand you have a problem. Hold east of Gill at 7,000. Expect further clearance at 35 past the hour."



The compass indication will lag when initiating a turn from a northern heading to the east. Turning from a southern heading to the east, the compass indication will lead the turn.

When accelerating on an east/west heading the compass needle points slightly north; when decelerating it will point slightly south.

Hold? A partial panel hold? Did the controller really say that?

Asking a partial panel instrument pilot to "hold" is like asking a man with a broken leg to just relax and do some jumping jacks until the ambulance arrives. The only explanation was that the controller was new and had nary a clue as to the demands he was placing on the pilot. That said, the newly certificated instrument pilot complied and began holding east of Gill at 7,000 feet as instructed. After all, he had practiced this drill over and over in his training. It was simply a matter of understanding how a magnetic compass works, and applying a few basic rules and procedures.

MAGNETIC COMPASS 101

For those who might not be comfortable with partial panel compass turns, let's rewind just a bit and review the basics of a magnetic compass—how it works, and how it responds in a real flight situation that includes accelerations.

For most pilots, the compass is something to which attention is paid only during preflight, and when verifying the DG setting. Certainly it has no practical value while in anything but straight and level, normal, unaccelerated flight. But for the student of instrument flight, the idiosyncrasies of the magnetic compass should be well understood. For most pilots, compass turns are just another one of those near-forgotten skills that can help pull your fat out of the fire when a worst-case situation comes out of the blue (or gray, as the case may be).

We all know that a magnetic compass has a magnetized needle that aligns itself with the magnetic lines of flux that surround our home planet. While we tend to think of those lines of flux as being parallel to the surface, such is really only the case when we're near the equator. As the lines extend north and south to the poles, they bend progressively toward the ground. At the magnetic north pole, the lines of magnetic flux are nearly vertical. In between the

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equator and magnetic poles, we say that the lines of magnetic flux have both a horizontal and vertical component, meaning they are aligned with the poles (horizontal component), but also bend toward the ground (vertical component).

The vertical components of the Earth's lines of magnetic flux are responsible for a phenomenon we call magnetic "dip," and the corresponding "dip errors" that occur in flight. When a magnetic compass is oriented level with the surface of the Earth, the magnetized needle aligns itself with the horizontal component. However, if we tilt the compass from the horizontal, such as when we bank the aircraft to turn, the compass needle will tend to also align itself with the vertical component of the magnetic lines of flux. Here in the Northern Hemisphere, that means the north-seeking end of the compass needle will tend to point toward the ground. That causes it to deviate from its proper alignment with the horizontal component of the flux, which is what we're really interested in.

TURNING ERRORS

Now that we grasp the basic problem of magnetic dip, let's look at what happens when we initiate a turn from a northerly heading. If we make a right turn (toward the east), the north-seeking end of the needle tends to point down as it aligns with the vertical component of magnetic flux. This causes the compass to indicate a turn toward the north. The net result is that the compass indication lags the actual turn. Eventually it will catch up, but especially in the early part of the turn, it appears to be "stuck."

A handy way to remember what error will occur when flying by the magnetic compass is "Lags ANDS Leads." In the north, the compass lags. In a turn to or from the south, it leads.

Turning to or from a southern heading has the opposite effect. If we make a left turn from a southern heading, the north-seeking end of the compass needle tends to point upward, which causes the needle to indicate a turn faster than the actual turn. In other words, the compass leads the turn.

ACCELERATION ERRORS

Dip errors happen not only when we bank the aircraft but also when we accelerate the aircraft on an east or west heading. This is because the needle rests on a precision pivot. In unaccelerated flight, it will float in a level condition. When we accelerate, the needle (or compass card) will tend to tip back, just as our head might, in response to the acceleration. During a deceleration, the compass card tips forward, again as our head might. Here comes the dip. On an east or west heading, the north-seeking end of the magnetized needle is pointing either left or right. If we accelerate in this orientation, the compass card tips back, allowing the needle to align itself with the vertical component of magnetic flux. The same goes when we decelerate.

The net effect is that when we accelerate on either an east or west heading, the needle points slightly toward the north. When we decelerate on an east or west heading, the needle points slightly toward the south. The way to remember this is "ANDS," which stands for accelerate north, decelerate south. Simple enough.

PUTTING IT TOGETHER

A handy way to remember what compass error will occur when flying by the magnetic compass is to remember "Lags ANDS Leads." In the north, the compass lags. In a turn to or from the south, it leads. So what to do with this? How can we adjust our turns so that we roll out on the headings we intend? The key to remembering that is "UNOS," which stands for undershoot north, overshoot south. Begin by always using a standard rate (shallow, or about a 10-15 degree bank) turn in small aircraft. Rather than starting the rollout 12 degrees before reaching the desired heading as we would with a DG, we adjust the rollout depending on the desired heading. The amount by which we undershoot or overshoot depends on the heading to which we're turning. If we're turning to an east or west heading, the error is minimal, so use the standard rollout lead of about 10 to 12 degrees. For a heading of north or south, lead or lag by about 30 to 35 degrees. On intermediate headings (roughly NE, NW, SE, or SW), lead or lag by about 15 to 20 degrees.

Example: We're flying west and must turn to a heading of 220 (roughly southwest). We would normally start our rollout at a heading of 230 (10 degrees before reaching the desired heading). But remembering UNOS, we know to overshoot south, so we start our rollout when the compass reads about 20 degrees past the desired heading, or when the compass reads about 200 degrees.

Making a turn to north from the east, we would undershoot north by about 30 degrees. When the compass reads 030, we start our rollout. By the time we're wings level, and the compass stabilizes, we should be showing just about dead north.

When making compass turns, we don't always end up on the heading we're shooting for, so some minor corrections might be necessary. If we're off a little, we can just correct with timed turns—making a standard rate turn, which is about 3 degrees per second. For a 10-degree heading error, a roughly three-second standard-rate turn will make the necessary correction.

LESSONS LEARNED

It was my student who was flying that day, and when I heard what had happened, I was fit to be tied. He performed flawlessly—at least in the technical sense—but I explained to him that despite his skills and talents, he never should have accepted the controller's clearance. The proper response would have been, "Five Alpha Delta unable to hold at this time; request no-gyro vectors for the ILS 9 at Weld County." But that's another story. EAA

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