Gyro Failure

Don't expect bells, whistles or flags—these things go slowly

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Coping with the failure of one or more gyroscopic flight instruments may not seem particularly difficult. After all, every instrument-rated pilot has had to demonstrate the ability to control an airplane without them. An instructor or examiner simply covers the artificial horizon and directional gyro and the student is left with the basics: needle, ball and airspeed.

But records of the National Transportation Safety Board indicate that many pilots are incapable of transitioning from full panel to partial panel when an actual gyroscopic failure occurs during instrument flight. Although such accidents are uncommon, they do have a relatively high fatality rate. Often, the victims are experienced and highly qualified.

Most pilots have little difficulty transitioning from full panel to partial panel while *practicing* because they are provided a fool-proof way of identifying a malfunctioning gyro. After all, if someone covers the gauge, it definitely is no longer usable. Shifting one's attention to the remaining instruments becomes logical and automatic.

Unfortunately, the *actual* failure of an attitude or directional gyro in the real world of IFR flight often is not so easily detectable. First of all, air-driven instruments are not equipped with fail flags. Secondly, the misleading data they provide often develops gradually, making detection more difficult. A pilot lacking a well-developed, *habitual* scan pattern may become unwittingly lured into a potentially hazardous attitude by an erroneous instrument display.

Several years ago, for example, a pilot departed a coastal, Northern California Airport toward an overcast, night sky in a Cessna 182. Although conditions were technically VFR, the natural horizon was not visible. After a normal takeoff toward the ocean, the pilot climbed to what witnesses estimated to be about 500 feet. The aircraft was then observed entering a shallow, power-on, descending turn to the right. A moment or so later, the aircraft impacted the water in a slightly nose-down, wing-down attitude.

Although his passenger-bride was killed instantly, the pilot survived with serious injuries. Subsequent investigation revealed that the vacuum pump shaft had sheared (possibly when take-off power had been applied), which allowed the attitude gyro to decelerate and tumble *gradually*. By apparently focusing his attention on this single instrument, the pilot became an unsuspecting victim of gyro system failure and blithely flew his craft into the Pacific. He followed the gyro's erroneous display because (1) there was no *immediately apparent* indication of gyro malfunction, and (2) he failed to respond to the contradictory attitude information available from other instruments.

Was this pilot a novitiate to instrument flight? Hardly. He was a 22,100-hour airline captain and general-aviation pilot with considerably more than 1,000 hours of actual instrument flight in his stack of log books.

This and other, similar accidents demonstrate clearly that even professionals can be guilty of excessive dependence on a single instrument, an instrument that could be failing gradually and subtly.

Let's be realistic. The artificial horizon is the center of attention. Through this single device, we have been taught to envision the outside world, to see "through" the panel to the natural horizon. But since the device is ordinarily so reliable, it tends to breed a form of complacency that promotes laziness. The discipline of scanning and cross-checking begins to decay. When the Cessna 182 pilot followed a failing gyro into the sea, other instruments shrieked silent warning of his neglect. But these were either unseen or ignored.

In addition to the artificial horizon, three other instruments should be used to *confirm* or *determine* variations in pitch: the VSI, altimeter and airspeed indicator. If all three suggest a descent, for example, while the artificial horizon indicates otherwise, the gyro display must be regarded skeptically.

The direction and amount of bank, however, may not be quite as easily determined, especially during cross-controlled or "uncoordinated" flight. For example, if the turn needle (or coordinator) indicates a left yaw and the ball is slewed right, what is the direction of bank? This *seems* to describe a skidding left turn and therefore a bank to the left. But not necessarily. The airplane could be yawing to the left with the wings level or even banked slightly right. Coincidentally, this is the presentation of a turn-and-bank indicator during a climb in a single-engine airplane when no corrective rudder is applied to compensate for the left-turning tendency.

The situation can become particularly confusing when the pilot does not recognize gyro-system failure prior to the development of a hazardous flight attitude when at a relatively low altitude.

Unfortunately, such a predicament is impossible to simulate and practice because an instructor cannot *gradually* fail one or both gyros without his student being aware of it. Either the gyros are covered or they are not.

Given enough time, a pilot ultimately becomes aware of the display discrepancy between an actually failing gyro system and the raw-data instruments. But can he determine and reject the erroneous data prior to becoming spatially disoriented in some unusual attitude? Perhaps. But if the failure occurs while the pilot is preoccupied with other cockpit chores at a relatively low altitude, the probability increases of his becoming a tragic NTSB statistic.

One of a pilot's best defensive weapons is to practice partial-panel flying routinely, develop an efficient scan pattern and apply these skills to every IFR flight. An effective scan pattern should also and occasionally include a glance at the vacuum (or pressure) gauge since this can be one of the few valid clues to suggest an impending gyro failure. Include the ammeter as well because a loss of electrical power can cripple the electrically driven gyro of a turn needle or coordinator.

Scanning alone is insufficient. The indication of each flight instrument should be correlated to the artificial horizon to corroborate this vital instrument's validity.

All of this goes to reinforce an IFR adage: "If an instrument pilot isn't always doing something, he's doing it wrong."

With respect to partial-panel technique, a relative newcomer, the turn coordinator, can be confusing during certain critical moments. Although the device is no more than a turn needle in disguise, the turn coordinator *looks* like a miniature artificial horizon. Unfortunately, there is a common tendency to use it like one and this can lead to worsening an unusual attitude.

As an FAA-designated examiner, I have observed instrument-rating applicants misusing the turn coordinator in such a way as to induce a spin entry while maneuvering at minimum-controllable airspeed without the benefit of a DG or artificial horizon.

For example, if the turn coordinator indicates a left yaw caused by a skid, the pilot may interpret the "symbolic airplane" on the instrument face to signify that the airplane is in a left bank. He promptly cranks in right aileron while on the verge of a stall which can combine with the skid to produce a left spin entry. (This is because of adverse yaw effect *and* the resultant angle-of-attack increase of the left wing produced by the downward deflection of its aileron.)

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Although the symbolic airplane of the turn coordinator *appears* to indicate bank angle, it alone does not. The symbolic airplane indicates only yaw. When confronted by an unusual slipping or skidding attitude that must be corrected immediately, a deflection of the turn coordinator clearly calls for the application of opposite rudder, an airplane's only method of direct yaw control.

Such advice may seem controversial to those who have been taught to "step" on the (slip-skid) ball and use ailerons to center the (turn) needle. Although this technique is usually adequate, it fails miserably when conditions become more precarious (such as when trying to recover from a spin while on instruments).

Most of the time, the needle (or turn coordinator) and ball are viewed in combination to perceive the condition of flight. When properly interpreted, a coordinated input of aileron and rudder corrects most attitudes or flight condition discrepancies. But if these indications cannot be assessed correctly and immediately to provide the "big picture" of aircraft attitude, use opposite rudder to arrest yaw and opposite aileron to center the ball. This method restores wings-level flight at all times and cannot induce a spin; the same cannot be said for "stepping on the ball" and "rolling away from the needle (or turn coordinator)."

Once the aircraft is under control, a pilot experiencing gyro-system failure should consider covering the affected gyros so that he is not again tempted to be misled by their erroneous indications.

He also should consider heading toward VFR conditions so that an IFR approach is not required while operationally handicapped with a partial panel. An ILS approach to minimums without the benefit of an artificial horizon and directional gyro is extremely difficult (especially with a bit of turbulence added for good measure). Most pilots are incapable of mustering the necessary skill.

But anyone who doesn't include himself in this category should try a partial-panel ILS to minimums while under the hood. It is a humbling experience.

If VFR conditions are not within range, try to find an airport that has a radar approach facility and request an Airport Surveillance Radar Approach (ASR). Without gyros, such an approach is simpler (and probably safer) than a "do-it-yourself" procedure. And don't worry if an ASR approach plate for the airport of your choosing can't be located; it may not be a published procedure. But this doesn't mean that such an approach can't be executed. During "emergencies," an ASR can be provided by most radar-equipped approach facilities.

In addition to providing more accurate course guidance along the final approach than an ASR, Precision Approach Radar (PAR) also provides descent guidance along a radar-generated glideslope. Unfortunately, PAR (commonly referred to as a ground-controlled approach, or GCA) is available only at some military installations and pitifully few civilian airports.

When an ASR approach plate is not available, the controller provides needed information such as the minimum descent altitude (MDA), missed approach point, missed approach procedure, etc.

An instrument approach to a north-south runway is most troublesome because of the compass's northerly turning error. Whenever the airplane is banked while on a northerly or southerly heading, the seemingly ornery compass responds by sashaying up to 30 degrees away from the actual heading. (The compass lags when turning from a northerly heading and leads when turning from a southerly heading.) Quite obviously, this makes it even more difficult to either maintain or change heading accurately without the assistance of a directional gyro. Given the option, therefore, it is much preferable to execute an approach to an east-west runway because on these headings the northerly turning error is nil.

If the destination airport does not have an east-west runway, it might be possible to execute a *letdown* to (special) VFR conditions on an easterly or westerly radar vector (assuming the ceiling is sufficiently high). Once the airport is in sight, a visual, circling approach to the available runway can then be executed.

To get this kind of radar assistance, however, it is suggested that a pilot advise the controller of the gyro-system failure. But don't expect too much controller flexibility at major air terminals such as LAX, SFO or JFK during the rush hour. Select a less hectic facility where controllers have more time and patience to help resolve a difficulty.

If a pilot prefers not to be responsible for turning to and maintaining specific headings, he can request a "no-gyro approach." This FAA-approved procedure requires only that a pilot begin and recover from turns in response to commands from the radar controller. For example, a controller might say "turn left," pause the appropriate period of time (depending on the amount of turn required), and then say "stop turn." All turns are to be executed at the standard rate (three degrees per second). After intercepting the final approach course, however, the pilot will be advised to execute subsequent turns at half the standard rate.

Some accidents attributable to gyro failure occur when pilots enter IFR conditions with known instrument malfunctions such as an abnormal fluctuation or unusual vibrations. Improprieties cannot be tolerated because these often are symptomatic of an impending, catastrophic instrument failure.

Even when the gyros appear to be functioning normally, there is a series of recommended operational checks that should be completed prior to every IFR flight:

- Check the vacuum (or pressure gauge shortly after engine start to confirm that system output is within limits. Consider that an excess of vacuum (or pressure) can be damaging because this may force gyros to exceed their rated speed (about 24,000 rpm).
- Be alert for unusual noises that signal internal bearing damage or wear. (This is best perceived in a quiet cockpit *after* engine shutdown.)
- Watch the instruments after engine start for abnormal vibrations and erection time. With respect to gyro erections, allow up to five minutes for air-driven gyros and three minutes for electrical gyros to reach full operating speed. (In the "Believe-It-Or-Not" category is the true story of an airline flight attendant who announced naively to her passengers that "the flight would be delayed at the gate for several minutes while the captain waited for an erection." A new vertical gyro had just been installed and required considerable time to spin-up properly.)
- Cage the directional gyro, set the heading indicator to coincide with that displayed by the compass and then simultaneously uncage the gyro and *twist* the knob. If the DG card continues to turn, the instrument is malfunctioning.
- During taxi to the active runway, the DG normally should not precess more than five degrees.
- While taxiing, execute gentle S-turns. During a left turn, confirm that the DG and turn needle (or coordinator) indicate a left yaw and that the slip-skid ball moves right. These indications should be similar but opposite during a right turn.
- During all taxi maneuvers, the artificial horizon should not indicate more than a five-degree change in pitch or roll (unless maneuvering on steeply sloped taxiways).
- Some instructors teach a method of stomping on the brakes while taxiing to demonstrate that the resultant pitching down of the nose is properly indicated on the attitude gyro. This is ill-advised because of the damaging acceleration loads that abrupt braking imposes on gyro bearings.
- Prior to cloud entry, be attentive for possible gyro malfunctions and glance again at the vacuum (or pressure) gauge for normal output.
- In flight, be aware that three degrees of gyroscopic precession every 15 minutes is normal for a DG. Substantially more warrants caution and investigation.
- Consider that the root cause of most air-driven gyro failures or malfunctions is contamination by impurities in the cabin air. These include moisture, dirt and tobacco smoke tar. To prevent such damage, keep smoking to a minimum and change gyro filters regularly. This applies to vacuum-driven gyros, not those powered by pressure or electrical systems.
- Minimize aerobatic maneuvers in those aircraft with gyros that cannot be caged.
- Consider that slight decreases in indicated vacuum (or pressure) over a period of several flights can indicate a decline in air pump efficiency and possibly an impending pump failure.

Fortunately, gyroscopic failure is uncommon, but uncommon doesn't mean never. Being aware of the possibility, however, is half the battle. □