FLYING LESSONS for February 14, 2019

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National Flight Instructor Hall of Fame inductee

FLYING LESSONS uses recent mishap reports to consider what *might* have contributed to accidents, so you can make better decisions if you face similar circumstances. In almost all cases design characteristics of a specific airplane have little direct bearing on the possible causes of aircraft accidents—but knowing how your airplane's systems respond can make the difference as a scenario unfolds. So apply these *FLYING LESSONS* to the specific airplane you fly. Verify all technical information before applying it to your aircraft or operation, with manufacturers' data and recommendations taking precedence. **You are pilot in command and are ultimately responsible for the decisions you make.**

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This week's LESSONS:

A twin-engine Cessna apparently broke apart and erupted in flames before diving out of clouds and into a house recently in Yorba Linda, California. Caught in horrific sound and video, the crash killed the pilot and four occupants of the home, and reportedly injured two others on the ground. Google the video if you feel the need to experience it yourself.

We have no idea yet what may have led to the Loss of Control – Inflight (LOC-I) that eventually resulted in the results caught on film. Whatever the causal chain—and the internet is alive with speculation as a result of allegations against the pilot involved—the outcome was predictable. Whatever the cause, the *result* was due to the natural characteristics of a stable airplane. In fact, the more stable the aircraft, the greater its tendency toward this scenario.

Fortunately, knowledge of this characteristic can help you anticipate and avoid the threat. The implications go beyond the scenarios usually taught as the focus of this hazard's risk. It helps explain many accidents in visual maneuvers as well as those in the clouds—and gives you ways to avoid those risks as well.

Killer Stability

There's a maneuver—easy both to enter and to recover from—that if left unchecked almost always ends in death. Almost *nobody* teaches this maneuver to aspiring pilots, and even many advanced pilots don't fully understand why a stable airplane naturally "*wants*" to enter this regime.

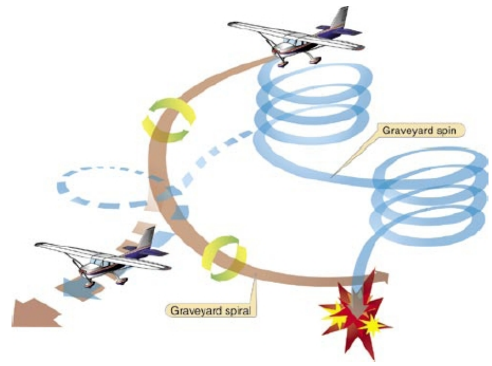
Practice steep turns and you'll learn something about this tendency. With an instructor or other knowledgeable copilot, on a clear, smooth day, get some altitude, clear the airspace, and slow the airplane to well below its maneuvering speed. Roll into a steep turn (anything more than about 35° of bank will do it). Now, ***let go of the controls***, and see what happens.

If your airplane is stable in pitch (virtually all type certificated airplanes are), it will do these three things:

- **Pitch** progressively further downward;
- **Roll** into an even steeper and steeper bank; and
- **Accelerate** more and more rapidly toward redline speed…and the ground.

You've entered what's often called the "***graveyard spiral***."

No, it’s not a spin



Although there are visual similarities, there’s a big difference between a spiral and a spin. A spin is the result of a stall while in uncoordinated flight, or (as usually occurs during intentional spin training) *forcing* the airplane into uncoordinated flight after the wings are stalled. In a spin, one wing is above its critical angle of attack and produces little lift while creating significant drag; the other wing is developing lift near its maximum lift coefficient while creating less aerodynamic drag. The contrasting forces create the **rotation** that is the hallmark of a spin.

A spin is a *stable* maneuver. The airplane will develop a pitch attitude, a rotational rate, a vertical speed, and an indicated airspeed (all sometimes deceptively low) and *hold it* so long as the pilot does not forcibly recover. Now, early in the spin it may seem as though the ***rates*** of rotation and descent and the ***angles*** of bank and pitch are increasing. But once the spin is fully developed, after a few turns or so, all of the variables remain constant…except, of course, height above the ground.

Given enough altitude (and skill in how to recover) a spin is a safe maneuver. When I checked out in the 1946 Cessna 120 I bought the week before earning my Private Pilot certificate, my instructor W.E. “Dirk” Dierking (who had taught Navy cadets in Waco biplanes as a civilian contract instructor during World War II) told me that in “the war” the accepted recovery technique if caught above a cloud deck without skills or equipment to fly IFR was to put the airplane in a spin, ride its stability through the cloud deck, then recover from the spin once in clear air beneath. Me, I prefer my instrument rating.

In many airplanes simply let go of the controls and the airplane will recover from a spin. Again, it only works well if there's enough empty space below the aircraft.

A spin, to repeat, **is a *stable* flight maneuver**. You won’t overstress the airplane in a spin unless you hit the ground.

A spiral, on the other hand, is **an *unstable* maneuver**. Unless the pilot corrects, an airplane in a spiral will develop progressively more aggressive pitch attitudes, bank angles, vertical speeds, and airspeeds. One of two outcomes is certain:

1. The airplane will run out of altitude and hit the surface; or
2. The airplane will exceed design speeds and G-forces and break apart in flight.

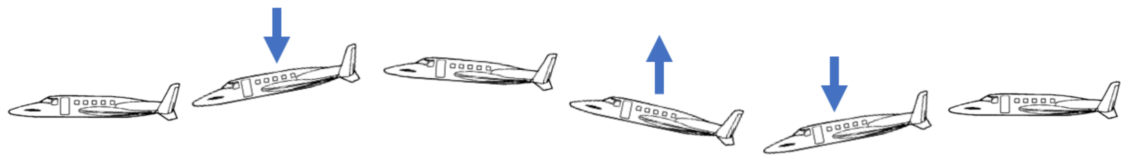
The outcome for the aircraft, its occupants, and anyone directly in its path is the same.

Instructors and pilot examiners briefly show pilots “unusual attitudes” (perhaps including the beginning of spirals) during training and checkrides, often in simulated instrument flight while “under the hood.” But briefing for, flying and debriefing unusual attitudes doesn’t usually include the word “spiral.” It may make a pilot think that the spiraling tendency applies solely to instrument flight. It doesn’t adequately explain ***why*** a spiral occurs, why it is “normal” for a stable airplane, or what needs to be done to avoid spirals in the first place. Let’s fill that gap in knowledge right now.

How Pitch Stability Works

A pitch-stable airplane is one that, once trimmed, will tend to maintain a constant airspeed…more correctly, a constant angle of attack (AoA). If something upsets the equilibrium, such as turbulence or a change in vertical wind speed, or if the pilot adds or reduces power, adds or decreases drag, or increases or decreases G load, then the airplane will pitch up or down as necessary to try to return to the trimmed airspeed/AoA.

The airplane may oscillate up and down several times, slowing beyond the trimmed speed and then nosing down, only to overshoot and get beyond trimmed speed and nose up to slow back down. Usually after two or three “porpoising” oscillations it will return to trimmed speed (although not necessarily on its precise original altitude).



A trimmed airplane, if disturbed, will attempt to return to is trimmed airspeed or angle of attack

That’s what a pitch-stable airplane does when disturbed…assuming it is in wings-level flight. But what about if it is in a bank at the same time?

Most airplanes have some amount of wing dihedral—the wings are mounted at an angle upward relative to the airplane, forming a slight “V” shape. This tilts the wings’ lift inward toward the fuselage slightly—changing its *lift vector*, increasing stability in bank. If the wings are banked slightly the dihedral effect tends to roll the airplane back into wings-level flight. High-wing airplanes often have less dihedral than low-wing types, or even no dihedral at all, because the weight of the fuselage beneath the wing acts as a pendulum that accomplishes the same roll-to-level effect from shallow angles of bank. Although it’s rarely employed, some airplanes have used anhedral, that is, downward-angling wings or an inverted V shape, to change the lift vector with the same net result.

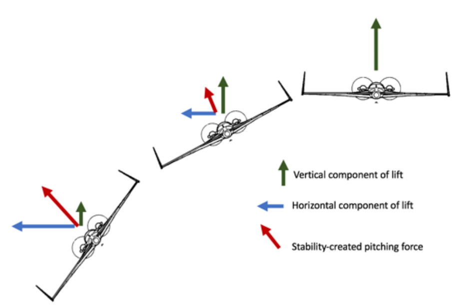
See https://en.wikipedia.org/wiki/Dihedral_(aeronautics)

What if the wings are banked in a *steep* turn? In most airplanes, once the bank angle exceeds about 35°-40°, it will continue to increase unless you apply some opposite aileron. CFIs generally do teach this: they call it the *overbanking tendency*. This happens because the lift vector is tilted too far for dihedral, anhedral or pendulum effect to correct on its own. Beyond a shallow bank angle, most aircraft are neutrally stable to slightly unstable in roll—they will not recover toward wings-level on their own, and may in fact tend to bank even more.

See https://www.faa.gov/regulations_policies/handbooks_manuals/aviation/airplane_handbook/media/11_afh_ch9.pdf

If you don’t notice the overbanking tendency or you do not properly correct for it, the aircraft will continue rolling. As the wing rolls away from the horizontal, there’s less and less lift holding the airplane up. Without vertical lift, the aircraft’s nose will drop below the horizon. If you’re banked to the left in most propeller aircraft the effect is even more pronounced as the left-turning tendency of the propeller pulls you “downhill.”

As the airplane's nose begins to point downward toward the earth the aircraft gains airspeed. Since a properly trimmed airplane will attempt to maintain a constant airspeed/AoA, it will now pitch “up”—relative to airplane, ***not*** the horizon. This “up” is pointed toward the center of the spiral. Pitching toward the center merely creates a steeper the bank angle, which reduces vertical lift more, which causes the nose to drop further, which causes even more speed, which makes the airplane pitch “up” even more…and so forth.



Spiral lift and pitch vectors

Once again, unlike a spin, in a spiral the airplane will develop a very high rate of speed and altitude loss. If you don’t correct it *soon*, you’ll either

1. hit the ground because of the tremendous vertical speeds, or
2. break up in midair because it exceeds the airplane's structural limiting airspeed and G force.

All of this can (and does) happen in a matter of *seconds*. You don't have to be close to stall speed, or exceed the critical angle of attack to enter a spiral—in fact the opposite is true. Because a spiral is not a stall at all, an angle of attack indicator will not warn you if you're entering or in a spiral, either.

Entering a spiral…

Spiral-type accidents are almost always the result of loss of spatial orientation. Although spirals are almost uniformly identified with attempted visual flight into instrument meteorological conditions, that is only one possible scenario. Others include night flight into or from a "dark hole" airport; distraction in the clouds, especially in turbulence; in the circling maneuver phase of a circling instrument approach; in the distraction or uncertainty of partial-panel flight; while practicing ground reference maneuvers; in a "botched" steep turn; during an attempt to return to the airport following loss of engine power shortly after takeoff; or even in a day, visual traffic patterns if a pilot gets distracted and doesn't recover in time.

Imagine you're **IFR**, level at Minimum Descent Altitude in a circling approach. The airport is in sight, but visibility is poor and raindrops are streaming up your windscreen. You're closer to the runway than a normal pattern because of the visibility, and you're lower than a normal pattern because of the cloud ceiling…if conditions were better you wouldn't be flying the circling approach in the first place. ***Or instead*** it's a dark night, and you're **VFR** in the pattern to a lighted runway that is in an area with few surface lights.

In either case your attention will be drawn to the runway itself—trying to keep it in sight during that circling approach, the only outside light source on that dark night. The visual cues make it easy to accidentally bank into a steep turn while focused outside the cockpit. If you get beyond about 35° of bank in most airplanes it will slide into a spiral. Airspeed will accelerate and vertical speed will increase to hundreds, even thousands of feet per minute very rapidly…and you have very little time to recognize the spiral and recover before you descend into the ground.

Quite likely a good percentage of what we call stall/spin accidents in the traffic pattern are, in reality, spiral-type mishaps.

…and Recovery

To recover from a spiral dive:

1. **Reduce throttle to idle.** Slow things down to reduce the overall stress on the airframe.
2. **Extend the landing gear,** in retractable gear airplanes, to reduce the rate of acceleration. Even if the airspeed is greater than gear extension speed (especially so, because that usually means the airplane is *very* fast), put the gear down. You may lose a gear door in a worst-case scenario, but the drag of the extended gear will help prevent exceeding V_{NE}—the structural "red line."
3. **Apply a little forward elevator**—just enough to unload the wing a bit, that is, reduce the G load that is the greatest threat to your survival at this point. It will also help prevent a stall as you continue your recovery by lowering the angle of attack. Notice that I wrote "forward," not "down." You don't want to deflect the controls toward the earth, you need to push the yoke or stick *forward* so the airplane pitches downward relative to the airframe.
4. **Roll the wings level.** Address the root cause of the loss of control. Use coordinated aileron and rudder to level the wings and stop the turn. Now the lift vector is "up" not only relative to the airframe, but also to the horizon. The airplane's tendency to pitch for airspeed/AoA will now work in your favor, helping you recover from the spiral and recapture lost altitude.

5. **Adjust your attitude.** Once the wings are level the airplane will pitch steeply upward, seeking its original, slower trimmed airspeed. Let the nose rise to a normal climb attitude to avoid overcorrecting and even more damaging stress. Then ***push forward*** on the controls to ***maintain*** that attitude. It may take a **very firm** push if your speed has increased a lot. This action reduces AoA and shortcuts the wild ride the airplane would otherwise take as a result of its pitch stability—with possible extremes of low speed/high AoA that could cause a stall, and high G load that could overstress the airframe, in the oscillations.
6. **Regain control.** Smoothly guide your airplane back to normal flight. Once at climb attitude with decreasing airspeed, add power and climb as needed. Apologize to your passengers and confess to ATC. If you got above V_A speed in the spiral, carefully land as soon as practicable and have a mechanic take a thorough look for damage.

All pilots should practice spiral recognition and recovery occasionally. With an instructor or other knowledgeable copilot on board, continue the demonstration introduced at the top of this article. Start with a thorough review and briefing of the maneuver and recovery technique on the ground. Then, on a clear, smooth day:

1. Climb to a safe altitude, clear the airspace of traffic, and slow the airplane to well below its maneuvering speed with the flaps up.
2. Roll into a steep turn (anything more than about 35° of bank will do it).
3. Let go of the flight controls. The overbanking tendency takes the airplane into a spiral.
4. Note the changing attitude and bank angle, the airspeed and the vertical speed. See how incredibly swiftly the rates and excursions become dramatic.
5. Before attaining V_A or descending below 1500 feet AGL, whichever occurs first, execute the spiral recovery technique.

Debrief the maneuver:

1. Imagine entering a spiral from traffic pattern altitude, or base-to-final altitude, or circling altitude in a circling approach. How much time would you have before impact if you blundered into a spiral from that height?
2. Imagine entering a spiral from cruise airspeed instead of the low speed you use during practice. How long would you have before exceeding V_{NE} (red line) airspeed if you entered a spiral from cruise?

Put most simply, ***a spiral is a steep turn gone bad***. If the untrained, workload-saturated or distracted pilot permits the bank to exceed about 35° and does not correct for the resulting loss of altitude and increase in speed, most airplanes will enter a spiral **as a result of their natural pitch stability**.

You can avoid spirals by:

1. Being aware of the overbanking tendency. Understand that, if you bank beyond about 30°, you may need to apply opposite aileron to maintain the bank angle, and add aft elevator and/or extra power to maintain height.
2. Avoiding bank angles beyond about 30° when you don't have a lot of room to recover, such as in the airport traffic pattern or a circling instrument approach.
3. Quickly cross-checking back and forth inside and outside the cockpit when in the visual scenarios conducive to spiral entry, to check bank angle as well as airspeed, altitude and vertical speed.

4. Regularly practicing instrument procedures, including partial panel flight and workload reduction techniques, to reduce the chances distraction will cause you to bank steeply and not recognize what happens next.

We generally don't go out of our way to show spirals to aspiring pilots, explain why and how they develop, or teach ways to avoid or recover from spirals. No wonder even the pilot of a piston twin might fall into the **killer stability** trap. Get some practice with an instructor familiar with the spiraling tendencies of your airplane and be ready to recover—properly—if you ever face this threat.

Questions? Ideas? Opinions? Send them to mastery.flight.training@cox.net

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Debrief: Readers write about recent *FLYING LESSONS:*

Frequent Debriefer John Sherer wrote about last week's *LESSON* on gauging takeoff acceleration, specifically the technique of comparing time to indicated airspeed to confirm (or deny) attaining 70% of liftoff speed when reaching 50% of the takeoff distance. John writes:

> I use the 70% of takeoff speed at 50% or calculated takeoff roll on every takeoff in our P35 [Bonanza]. I use the runway lights to gauge distance. They're 200 feet apart at my airport. Convenient. You can also find a spot on the runway corresponding to your expected liftoff point by using the scale on the Jeppesen Approach chart.
>
> In the [US Air Force] C-5 [Galaxy] on heavy takeoffs, we calculated an ***acceleration check time***. The flight engineer gave us a time to go speed minus ten knots. If not [at that speed] within 3 seconds, we would abort. I remember some long times, like 45 seconds to 120 knots. Some takeoff rolls in a heavy C-5 could be one minute ten seconds—an eternity on the runway. (With the old engines, the C-5 was a ground loving airplane above about 700,000 pounds)
>
> I time every takeoff [when a passenger] on airliners. They're almost always 35 to 45 seconds. On a trip from Zurich to O'Hare in a Swiss Airlines 777-300ER, the takeoff roll was 46 seconds. This week on a 737-800 (Southwest) from San Jose to St Louis, it was 36 seconds.

It would be a challenge for the pilot of a light airplane to come up with a time-to-70%-liftoff-speed table—you'd have to know 50% of the takeoff distance, identify it using runway lights, runway stripes or some other reference, and then time to see how long it takes to get there in a normal-acceleration takeoff. You'd then have to do this at various weights and density altitudes. The result, however, would be very helpful for the time you're making a heavy and/or high density altitude takeoff…and for doublechecking every time, even taking off from the home airport at "normal" weights. Thanks, John!

Reader Rick Baron writes about a *LESSON* last November in which I discussed taxiing and landing on the centerline as a measure of effort and professionalism that pays off when landing in narrow runways, taxiing in tight areas, and winter operations when plowed snow is along the edges of surfaces:

> I'd rather land safely a bit off center line than unsafely on center line. Becoming obsessed about the center line could actually cause more harm than good in some circumstances.

I replied: I strive for both, as I'm sure you do as well. If I miss on either count, I'll figure out why and work to fix it next time. I think I see your point—to accept a landing off-center instead of making a wild control input at the last minute to get on centerline. I certainly agree with that.

See http://www.mastery-flight-training.com/20181108-flying-lessons.pdf

Questions? Comments? Suggestions? Let us know, at mastery.flight.training@cox.net

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