FLYING LESSONS for May 10, 2018

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:

The NTSB reported last week:

> …a North American SNJ-5 airplane impacted terrain following a loss of control during initial climb after takeoff from runway 13R (8,000 ft. by 200 ft.) at Kingsville Naval Air Station (NQI), Kingsville, Texas. The pilot and pilot rated passenger were fatally injured and the airplane was destroyed. Visual meteorological conditions prevailed. The flight was originating at the time of the accident and the intended destination has not been confirmed.
>
> Witnesses reported that the airplane took off on runway 13R and had requested a right-hand teardrop turn for a departure toward the north. The **witnesses reported seeing the airplane in a steep right bank with some witnesses reporting that the bank angle exceeded 90 degrees of bank. *The airplane descended nose low*** and the right bank angle lessened before the airplane struck the ground.

See https://app.ntsb.gov/pdfgenerator/ReportGeneratorFile.ashx?EventID=20180425X44849&AKey=1&RType=Prelim&IType=FA

Stalls and spins get the lion's share of coverage in instruction and in article and videos concerning Loss of Control – Inflight (LOC-I). To be sure, stall/spin events are hazards requiring this focus—the record shows that LOC-I events are the most common fatal accident scenario, and most LOC-I events appear to be stalls that often develop into a spin before impact.

There is another LOC-I sequence that is neither a stall nor a spin. It is a natural outcome of aircraft stability, and a characteristic of all longitudinally (pitch) stable airplanes. Yet it is not mentioned by name, trained, or evaluated for or in the Practical Tests for pilot certificates or ratings. The sequence is a *spiral dive*, and it's what witnesses in the SNJ crash seem to describe.

Here's how the U.S. *Airplane Flying Handbook* explains a spiral, with my emphasis added with **bold font**:

> A spiral dive, **a nose low upset**, is **a descending turn** during which **airspeed and G-load can increase rapidly** and often results from a botched turn. In a spiral dive, the airplane is flying very tight circles, in a nearly vertical attitude and will be accelerating because it is no longer stalled. Pilots typically get into a spiral dive during an inadvertent IMC encounter, most often when the pilot relies on kinesthetic sensations rather than on the flight instruments. A pilot distracted by other sensations can easily enter a slightly nose low, wing low, descending turn and, at least initially, fail to recognize this error. Especially in IMC, it may be only the sound of increasing speed that makes the pilot aware of the rapidly developing situation. Upon recognizing

> the steep nose down attitude and steep bank, **the startled pilot may react by pulling back rapidly on the yoke while simultaneously rolling to wings level. This response can create aerodynamic loads capable of causing airframe structural damage and /or failure**.

The *AFH* recommends this spiral dive recovery technique:

1. Reduce Power (Throttle) to Idle
2. Apply Some Forward Elevator ("unload the wing," i.e., reduce the G load)
3. Roll Wings Level
4. Gently Raise the Nose to Level Flight
5. Increase Power to Climb Power

See https://www.faa.gov/regulations_policies/handbooks_manuals/aviation/airplane_handbook/media/06_afh_ch4.pdf

This excerpt doesn't explain *why* an airplane will naturally enter a spiral or *how* such spirals develop. ***This lack of emphasis in training syllabi and complete absence in Practical Test evaluation means many—perhaps most—pilots may be unprepared to recognize and recover from a spiral.*** Let's delve into why I say a spiral is a natural outcome of aircraft stability, how a pilot may enter a spiral (it's not just an attempted visual flight into IMC phenomenon), and why knowing about spirals is important to VFR-only and instrument pilots alike.

Stability, steep turns and spirals

Most airplanes exhibit some level of stability in at least two of the three axes. Almost all have built-in **pitch** stability. Disturbed upward or downward in pitch and then released, the airplane's nose will oscillate up and down through two or three cycles before it returns to its original pitch attitude…not necessarily on its initial altitude, but at the same pitch attitude, angle of attack and indicated airspeed.

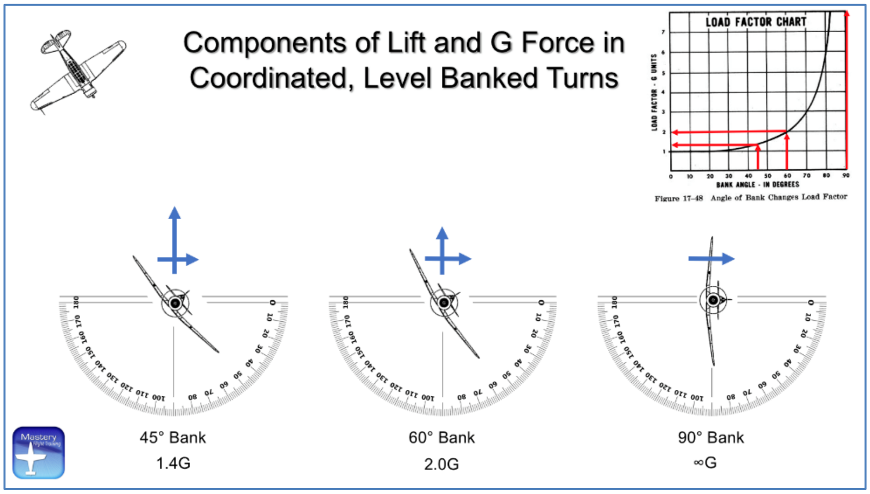
Put another way, a pitch-stable airplane will seek the indicated airspeed (actually, angle of attack) for which it is trimmed. If it is disturbed in pitch, or if power or total drag (flap, landing gear position) changes, the airplane will pitch down or up as necessary to remain at its trimmed speed. **Important note:** The load factor ("G load") on the airplane will increase *only* if the pilot, an autopilot, or a runaway electric trim system resists the airplane's natural tendency to change pitch if it gets off its trimmed speed. ***An airplane will not stall on its own.* The pilot (or an automated pilot) has to actively pull against the airplane's stability to *make* it stall.**

Most airplanes also have some level of stability in **yaw**. Kick a rudder pedal and release, or hit a wind shear that yaws the aircraft, and it will wallow back and forth a few oscillations before returning to straight-ahead flight.

Many aircraft are neutral in stability or even slightly unstable in **roll**. Enter a shallow bank and the airplane may remain banked or slowly return to approximately wings-level flight. But bank steeply enough and most aircraft will *not* level their own wings. In fact, in a steep turn most airplanes will continue to bank progressively more steeply. This is sometimes called the *overbanking tendency*, the reason it may take opposite aileron input to maintain bank once established in a steep turn.

See https://docs.lib.purdue.edu/cgi/viewcontent.cgi?referer=https://www.google.com/&httpsredir=1&article=1107&context=jate

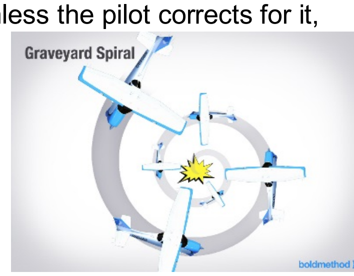
You've probably seen graphs and diagrams that show the relationship between bank angle and stalling speed. What's not often well-explained is that this relationship is only valid in level, coordinated flight. If the pilot does not resist the airplane's tendencies and its nose drops to seek the trimmed airspeed, the G load does not increase (or it increases some, if the pilot applies *some* but *not enough* resistance to maintain level flight).



What happens, then, if the airplane enters a steep turn and the pilot provides more or less resistance than is necessary to maintain level flight? We'll use the 60° bank example simply because we can speak in whole numbers:

- If the pilot adds more that 2G of resistance, the airplane will climb. The nose will rise above the horizon and, if there is sufficient power, the airplane will enter a sustained climb. With insufficient power the wing will quickly enter an accelerated stall.
- If the pilot applies exactly 2G of resistance the airplane remains level. Airspeed will decrease from the drag of high angle of attack flight, so the pilot will have to add power to maintain airspeed. If airspeed increases the airplane will climb, or the pilot may reduce back pressure—more power means the same G load is sustained at a lower angle of attack. If airspeed decreases the airplane will descend—its nose will drop below the horizon, seeking to attain and maintain the trimmed airspeed.
- If the pilot does not apply at least 2G of resistance with elevator, power or both, the airplane will descend. Its nose will drop below the horizon, seeking to attain and maintain the trimmed airspeed.

Further complicating this is the overbanking tendency. Unless the pilot corrects for it, once in a steep turn the wing will continue to bank further. This means the nose will drop even more. The airplane, now sensing more airspeed than that for which it is trimmed, will naturally pitch *upward* to return to the slower, trimmed speed. Except this pitch change is "up" relative to the airframe, not relative to the horizon. In a steep (and getting steeper) turn, this just tightens the downward spiral, increasing airspeed even more. Airspeed and vertical speed increase incredibly fast. As bank angle and speed increase, G load increases to (and eventually beyond) the airplane's structural limit.



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Put most simply, a spiral is a steep turn that the plot allows to go bad.

One of five outcomes results:

1. The pilot recovers from the spiral using the recovery technique described earlier.
2. The airplane spirals rapidly into terrain.

3. The airplane is high enough at the entry into the spiral that it has time to accelerate beyond V_{NE} before it impacts terrain. Exceeding structural load limits causes the airplane to break up in flight.
4. The pilot does not recognize the spiral for what it is, or does not know the proper recovery technique, or panics. She/he pulls back on the controls, perhaps instinctively. The G load builds and overstresses the airframe; the airplane breaks up in flight.
5. The pilot attempts a recovery but does not apply *forward* control pressure to unload the wing. The airplane exceeds structural limits in the pullout and breaks up in flight.

Those sequences may sound familiar. One of them is usually the outcome of attempted visual flight in Instrument Meteorological Conditions ("VFR into IMC"). The same goes for a thunderstorm or other strong turbulence encounter, even for an instrument pilot.

I also relate an airplane's natural spiral tendency to the hazards of the visual portion of an IFR circle-to-land approach and to landing at a "dark hole" airport at night. In both situations visibility is reduced; the pilot is unusually focused on the runway, trying to keep it in sight; and unusual visual cues tempt the pilot into flying steep banks close to the ground.

Frankly, I think more airplanes impact the ground out of spirals entered from uncorrected steep banks in the traffic pattern, that is, ***the pilot not doing enough*** because of distraction and letting the airplane do what it wants, than crash from stall/spin mishaps resulting from **the pilot doing too much**, i.e., resisting the airplane's tendencies and intervening (albeit incorrectly). That was the impression I got tramping around an aircraft salvage yard evaluating the patterns of aircraft wreckage in (*FLYING LESSONS* reader) Fred Schieszer's Air Crash Investigation course at Central Missouri State University a long time ago, anyway.

Let's go back to our example, the SNJ departure crash. The pilot clearly intended to make a right-turning departure; he asked for permission to do so. I interpret a "right hand teardrop turn" from Runway 13 for a departure to the north to mean a tight turn to overfly the airfield, as contrasting from a more conventional left turn on course after departure. An airshow-type, Navy-historical airplane departing from an air show at a Naval Air Station in this "look at me" departure path at least *suggests* the pilot intended to make a fairly steep turn shortly after lifting off. It's at least consistent with what I see at air shows all the time.

So if a pilot plans such a departure, what does that pilot need to be thinking about?

- "If I am going to bank 45° while climbing I will need to exceed 1.4G in the climb or the airplane will descend into a spiral entry."
- "If I am going to bank 60° I will need to exceed 2G in the climb or the airplane will descend into a spiral entry."
- "I should not exceed 60° bank in the climb because G load required will increase exponentially and the airplane will either stall or slide into a spiral entry."
- "If at any point the airplane begins to descend all I need to do to recover is to reduce the bank angle and unload the wing."
- "Is this even a good idea at all? What are my margins, and is there any real benefit from the added risk?"

We don't know yet if there was an engine issue, or the pilot pulled into an accelerated stall, or if there was some sort of control issue, or whether there were medical or other issues that led to the flight path that witnesses described. Whether a spiral was a factor in the SNJ crash or not, though, perhaps you know a little more about spirals and how to avoid them now because of it.

Comments? Questions? Let us learn from you, at mastery.flight.training@cox.net

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