SOARING Rx

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How to Spin *Unintentionally*

Try to stay in the middle of the air.
Do not go near the edges of it.
The edges of the air can be recognized
by the appearance of ground,
buildings, sea, trees,
and interstellar space.
It is much more difficult to fly there.
- unknown wit

Thesis: Most gliding fatal accidents occur due to stalls (Rich Carlson, SSF). Most of these occur close to the ground, usually in the turn from base to final, but they also occur, surprisingly, during free flight.

What are these pilots paying attention to? What might have been done to avoid this? More to the point, what are pilots doing who *never* stall inadvertently?

The principle is simple: don't skid slow turns, and; he who skiddeth a slow turn stalleth, spinneth, and (quite possibly) dieth. Note carefully: Unless any turn is perfectly coordinated, we either are skidding somewhat or slipping somewhat. The skid – bottom rudder – tends to create a spin. The slip – top rudder – "improves" the sink rate, safely.

Caveat 1: this and all other discussions of aircraft control assume smooth air. In turbulence, whether in the pattern or in a thermal, small turbulent vortices may betray your best intentions – a reason to then carry extra speed.

Caveat 2: A discussion of the relationship of the yaw string to coordinated flight becomes, frankly, somewhat complicated in a slow, steep turn in turbulence, especially with long wings. In fact, what people mean by "coordinated flight" becomes rather vague:

- Does it mean straight flow of air over the canopy? (straight yaw string)
- Does it mean the net "gravitational" vector pointing straight down? (centered ball)
- Does it mean drag is balanced between the wings?
- Does it mean that each wing is about equally far from stalling?

These things are easy to synchronize when nearly level (up to a 30-degree bank). But as the turn becomes steeper, it becomes impossible to meet all four of these conditions simultaneously. Most important, a centered yaw string no longer means that each wing is about equally far from a stall.

In a steep turn, the yaw string and the ball become less relevant to safety. The position and responsiveness of the controls is more important. If the stick is against the high-side stop (due to overbanking from differential lift), you have no control in the roll axis. This causes anxiety when turning steeply, slowly, in a narrow, turbulent thermal.

All you need to do is add enough top rudder to balance the drag (reduce the down-wingtip angle of attack) – this restores roll control very nicely, and you'll be able to comfortably make continual steep turns in any glider or airplane. When you do this in an airplane, you may be a half-ball off center, and in a glider, the yaw string may drift 10 or 15 degrees to the top side.

Therefore the safe pilot is maintaining balanced controls, "coordinated" or slipping but never skidding. The pilot is in danger who is, while turning slowly and steeply, cluelessly loyal to the instruction, "always center the yaw string." It's *not,* just then, important to center the yaw string. It's *important* to maintain control responsiveness (with speed) and to maintain "coordination" that keeps the stick near the center, so there's margin for roll correction in either direction.

The yaw string in that moment, due to turbulence or normal awkwardness, will wobble back and forth between a slip and a skid, "centered" *on the average.* But the wing does not care about its average airflow; it cares about each moment's flow.

"The middle of the air" (metaphorically) is the safe place to be, but the centered yaw string, in a steep turn, is at the border between a skid and a slip, so a (literally) centered yaw string is (metaphorically) "on the edge of the air" in a slow turn. Humorously, an actually-middle yaw string is metaphorically at the brink of the cliff.

Thus, we should prefer the yaw string to flop between center and our high side, not crossing the center to the low side.

"Attention," as we explained last month, acts through built-in brain networks that can be improved with training and practice. Instructors use words like "protocol" and "discipline" to describe the result of successfully training the attention networks.

We must train attention toward the most important things while turning, especially while landing. Training done well teaches the pilot to shift attention among various key items during the changes of flight, landing, and takeoff, and teaches disciplined rigor to this attention protocol.

To teach, "keep the yaw string centered," is a good thing as a general principle, but religious obedience to this pedantry is not a good thing, if by this we come to believe that it defines piloting virtue, or believe that a centered yaw string always indicates coordinated flight, or that it's most important to keep it centered.

This would be inexact.

- The yaw string indicates the direction of airflow in which it lives. Coordinated flight centers the yaw string in straight and level flight. In turns, this isn't always precisely true.
- Coordinated flight, in a steep turn, is not the safest condition – it's the most elegant condition. If the goal is to stay "in the middle of the air," midway between dangers, a centered yaw string does not keep you there in a steep turn.
- Keeping our attention on centering

the yaw string distracts us from paying attention to other much more important details like airspeed, aim point, angle of attack, apparent flight track, other traffic, and obstructions on the runway.

Perceptions are crucial. There are three perceptual features that may delude a landing pilot into flying too slowly or skidding a slow turn:

- the horizon,
- *vection,* or the sense of speed, and
- the movement of the down wingtip across the ground.

Our surround changes during descent in the pattern, creating three misperceptions that trick landing pilots:

- The horizon begins to rise. If we keep the nose at the same point on the horizon as we did when high, we will steadily slow down. (Fail!)
- The ground moves faster and faster. We may slow down to make this *feel* right. (Fail!)
- The down wingtip moves forwards across the ground. This may cause us to feel that:
- We are failing to turn with the intended small radius. This may inspire us to step on the inside rudder (Fail!)
- We are moving too fast. This may cause us to induce back pressure to slow down. (Fail!)

How is this relevant to the yaw string?

Simply this: There's no one thing that we can fixate our attention to, and remain safe. The loyal yaw string, the wingtip, the horizon, the sense of motion: none of these is enough. We should also pay attention to the wind noise, the control responsiveness, and – most important – where we're headed, the apparent and the intended touchdown points (these are different). We need to *scan* these, we need to *integrate* the information they provide with our knowledge and experience.

If we are watching only the horizon, or the ground under us, or our wingtip, we may cause the yaw string to point down toward hell, or cause the airflow to lose its affection for our wing, which may take us there.

So, for a left turn:

Yaw string left (down)	Yaw string centered	Yaw string right (up)
Death, fear	Excitement, glory	Life, safety, slop, descent

Here's how the perceptual bits work to take us out of "the middle of the air."

The rising horizon

This is not as serious an issue in the flatlands, where the effect is pretty subtle. But when there are hills or mountains nearby, it is serious. While we're above everything, we see the real horizon. As soon as we descend below any hump of earth, its ridge line becomes a false horizon.

To understand that the ridge is a false horizon is easy; to keep track of where the real horizon is located takes actual attention. Look down the valley. Find the true horizon. Swivel your head back and image that horizon line onto the mountain. Do this several times while you descend – if you don't, you will tend to raise the nose.

If you don't keep track of the actual horizon, for example by "transferring" it to the mountain, your subconscious perceptions may cause you to feel as though a strong hand is pulling the stick back while the airspeed decays mysteriously, over and over again, (which a pilot at the Reno convention asked me to explain).

But why are you paying attention to the horizon, anyway? It's *airspeed* we want, and we put the nose at *whatever* attitude keeps the airspeed where it's meant to be: 1.3 VSO + ½ the gust velocity (more, if it's really gusty). If you're trying to fly attitude in the pattern *instead of* managing airspeed, it's time to do some serious practice to revise unhelpful habits of attention. (*Correct* practice leads to correct decisions.)

Vection

Vection is *apparent movement*, in distinction to actual movement. The classical vection illusion is you sitting in a stopped train, and beginning to move smoothly backwards – until you realize from the lack of vibration that it's the train on the other track moving forward.

There's a similar vection illusion when we are up high – it seems as though everything on the ground merely creeps past. And a complementary illusion when we are low – the ground seems to race past. Both are "wrong" – neither is wedded to the airspeed indicator.

We may get in trouble because we spend too much of our time soaring and not enough doing pattern tows. Our brains then build perceptual patterns that don't include the sensations of low-level flight. A reason to go to the airfield and do pattern work on poor soaring days is to rebuild these low-level gestalts, so that our brains easily shift from the high-altitude to the low-altitude vection sensations as both being normal and expected.

The speed at which the ground seems to move is also related to the objects-texture. When we fly from a novel airport, the texture of ground objects may be much different than we are used to, and unless we discipline ourselves to be conscious of this difference, the novel vection sensations at the new airport may be grossly deceptive.

The answer to this deception is the same as for the false horizon: include the airspeed indicator in our scan – fly whatever attitude keeps the needle on the best hash mark for the conditions.

The pivotal altitude

The pivotal altitude is the altitude at which the apparent wingtip movement across the ground in a turn changes, and finding this altitude is the key to performing ground reference maneuvers well.

If you have an airplane rating, you have had to do ground reference maneuvers, classically turns about a point and pylon 8s. These aren't really possible in gliders, because we can't sustain a constant altitude reliably, especially at the pivotal altitude at which these must be flown.

To take another view, the pivotal altitude is the altitude at which the down wing can be kept on one apparent ground point. (Y'know, if you've never done ground reference maneuvers, or don't clearly recall doing them, go get three or four hours of airplane instruction until you can do them comfortably, in some wind.)

Above the pivotal altitude, the down wingtip seems to move backward over the ground as we turn; below this altitude, the down wingtip seems to sweep forward across the ground as we turn. In addition, while performing these turns, when we rise above the pivotal altitude, the airplane *seems* to slow more than it actually does. When we descend below the pivotal altitude, the airplane *seems* to accelerate when it may be slowing.

Ground reference maneuvers are totally relevant to flying safely in the pattern. Whether in gliders or airplanes, if we are in a turn as we descend through the pivotal altitude, we experience a *vection illusion* as the ground *appears* to speed by more rapidly as we descend, even if our ground speed is constant: we *feel* or "*observe*" acceleration.

This will cause reflexive slowing, in response to subconscious processing of these misperceptions, unless we discipline ourselves to keep glancing at the airspeed indicator.

A second vection illusion as we descend in a turn through the pivotal altitude is *the sense of a decreasing rate of turn*. Why is this? While above the pivotal altitude, in a constant-radius turn we *observe* the radius to be relatively tight because the wingtip is creeping backwards across the ground. After we pass below the pivotal altitude, we *observe* the radius to have decreased, the turn to have widened out, because the wingtip is now creeping *forward* across the ground.

The combination of these two vection illusions – of increased speed and decreased turn radius, will naturally cause a strong inclination to step on the inside rudder to correct what seems like a decreased rate of turn and to raise the nose to correct what seems like excessive speed (compared to a few seconds before). The false sense of high airspeed is especially important flying the downwind leg on a windy day, when airspeed discipline in the turn to base extremely important or a stall-spin can end your day in the worst way.

This combination is all too likely to take us out of "the middle of the air." It may make the controls feel less responsive (sitting here in our armchair, it's obvious that this is due to mushing, an imminent stall – but in the glider we are not so prone to disbelieve our senses, as we are built to give visual cues higher priority than tactile ones).

Again, the answer is to discipline ourselves to pay attention to the important items: the airspeed indicator, turn coordination, and our aim point for landing. If we take care of these, we will be rescued from our own senses.

Don't Center the Yaw String!

Here's the deal. In an *imperfect* world, in a steep turn (45-60 degrees), when going slow, "the middle of the air" is bounded on one side by the center of the canopy. If we touch top rudder and the yaw string drifts high, we may feel (and possibly look) sloppy, but we are safe. (And who knows, maybe we could stand to lose a little extra altitude in a slip.)

But if the yaw string drifts to the low side of center, we may not only look sloppy, we may spin, and may look very broken, on the hard ground.

If we have a ball in the panel, depending on the shape of our glider and the position of the yaw string, we may discover at times that the ball is about centered while the yaw string is going adrift.

To repeat: all you need to do is add enough top rudder to balance aileron drag – this restores roll control very nicely, and you'll be able to comfortably control continual steep turns – in other words, to thermal.

Stall-Spinning in Free Thermaling Flight

This analysis is all well and good close to the ground, but pilots are also stall-spinning up high. There aren't the same illusions up there. What could possibly be happening? Besides, there's room to recover!

We all understand what's happening aerodynamically – the longer the wings, the steeper the turn, the slower the airspeed, the more likely that the down wing will stall. The airplane rotates faster, the nose drops.

Perhaps a problem is that the pilot's brain may not be fully in gear. Sitting here in our armchair, it's all so obvious. And when the stall or spin is done in training, we're *trying* to make it happen, and it's *expected.*

My own instinctive perception with an unintended stall-spin is, "Oh, the controls stopped working! Is something broken?" This is because an abrupt stall, in a turn, usually precipitated by a thermal gust, occurs *without* a preceding change of bank angle, attitude, or airspeed. It simply *happens.*

Then there's a distinct thought shift, a moment of clarity. "Doh. It's a spin."

Relax back pressure, center the ailerons, top rudder. Level off, turn back to re-center the thermal we just lost.

Second, we're taught to fear stalls, by many influences, such as this essay. If we've got altitude, there's no reason to fear them at all. I've entered many, many inadvertent stalls and incipient spins while thermaling (back in the days when I ignorantly thought the yaw string must always be centered). I'd been urgently warned: "Be careful not to spin! Those glass ships really pick up speed fast!"

My experience is the opposite. Abrupt, yes. Scary, no. Pick up speed fast? Well, sorta – and I'm glad, because the airspeed quickly ends the embarrassment. After a while, I came to enjoy these. They don't help the average climb rate any, but in my glider they are gentle; in a way, a nice break from the tedious struggle to keep a thermal centered for the half-hour it may take to figure out where the top is located in a narrow, turbulent but lazy, midwestern thermal.

(And please don't play with that if anyone's sharing the thermal!)

Again, there are really two problems:

- One, we weren't planning on a stall-spin. We haven't changed the aircraft attitude, the controls simply quit working. Since a spin wasn't on the agenda, our mind may be completely elsewhere, and we may reflexively pull back the stick (the aileron will already be full-deflection toward the top wing due to our ignorant ambition of having the yaw string centered), and the controls truly *don't* work for a moment.
- Two, we might panic. This tends to cause brain freeze, focusing on "Why did the elevator fall off?" Which if it had, the nose would fall and the stall end. Yet if the brain is frozen, the result is the same, either way.

Bill Daniels related to me an accident like this, decades ago at Torrey Pines, in which a 2-seat glider was seen to stall-spin from free flight, doing 24 turns; the witnesses near the impact site heard the pilot and passenger screaming all the way into the ground.

A horrible, needless tragedy like this happens every so often. But there's more: it's not merely the pilot.

The March-April, 2014, issue of *Gliding International* described a fatal stall-spin in an ASW-27 while thermaling. The subsequent lawsuit involved whether the deceased pilot had been instructed that this glider could enter an unrecoverable spin. (This is not the only aircraft that may in some conditions enter an unrecoverable spin.)

The fact that unrecoverable spins can occur is a reason to keep the yaw string on the safe side of center, to slip turns a bit to maintain full control authority, and to practice recovery from incipient spins.

To reduce the risk of spins from thermals, I can think of three things to practice:

- During checkout and check rides, routinely do stall-spin maneuvers during thermaling turns, so they're familiar. It's the *entry* that's important, and a prompt recovery, ideally while the spin is *incipient*.
- During any instruction, the instructor should sometimes gradually enter a thermaling stall and say, "your ship" just as it's about to begin. The debriefing should cover recognition, recovery rate, and control technique.
- Instruction about stalls and spins should be focused on resolving fear. Make the incipient spin feel familiar, so it becomes a normal-seeming part of flying at altitude, and the pilot response automatic.

Spin-*avoidance* training has its place and is important – we don't want ever to feel comfortable with an incipient spin in the pattern, for example. Nor is it particularly important to push along to fully developed, multi-turn spins. But the incipient spin, in a thermaling turn, in turbulent air, is common enough that we should train for it as a normal part of flight.

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