FLYING LESSONS for
July 9, 2020

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 friend and flying student made a long cross-country flight recently. After he returned he mentioned that takeoff performance was sluggish on almost every takeoff. He’d followed the proper procedures, including leaning for maximum propeller speed prior to takeoff in the fixed-pitch propeller airplane. Even then, he said, the airplane took a lot more runway than usual to lift off.

I’d watched his progress on the multi-day trip. I reminded him that with one exception his takeoffs were all made in the heat of a summer day (his takeoff for the first leg homeward was the only one made early in the morning). Then we talked about the concept of runway temperature.

Runway temperature, the temperature of the air over a paved runway, can be as much as 40°F (a difference of roughly 20°C) above that reported by ATIS, ASOS or AWOS on a hot, sunny day. The atmosphere warms from the surface up. Solar radiation is absorbed (or reflected) by the surface; the air just above the surface is then warmed by contact. Warm air will rise, but the greatest heat can dissipate a short distance above the ground—or the runway.

That is significant, because it’s that lowest level of the air that determines an airplane’s takeoff performance. The wing, especially in low-wing airplanes, is clawing through this layer to develop lift for takeoff and depends on the drag from this air to match distance expectations during landing. The engine is sucking on this hot, low-density air to combine with fuel to turn it into power. If the airplane is propeller driven, the prop is chewing into this lowest level of air to turn that power into thrust.

Be very conservative about performance margins when departing or landing any paved runway on a hot, sunny day. The airplane will probably not perform even as well as a careful performance calculation may predict, if the reported air temperature is the basis of the calculation. As you come in to land, you may have a loss of performance, a sudden sink on glidepath as you cross a paved threshold and enter the low-density air over the runway. Be ready.

Add the concept of runway temperature, and you should be leaning the mixture for best takeoff power and monitoring the airplane’s takeoff performance when departing any runway at any elevation.

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

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Debrief: Readers write about recent FLYING LESSONS:

Reader and aerobatics instructor Tony Johnstone wrote about last week’s Debrief comments and those the week before that, regarding “rolling Gs” and the more elementary concepts of what make an airplane turn:

Regarding lift and turn, I have asked this question many times in my spin training class: “which flight control makes the airplane turn?” Generally I get about 50% say ailerons, 30% say rudder. Obviously horizontal lift makes the airplane turn, and since elevator (i.e., angle of attack) controls lift it is the elevator that makes the airplane turn! We demonstrate this in flight, roll the Decathlon into a 60° bank with the wing unloaded [pushing forward stick to attain zero G—tt]. No pull, no turn. Then pull, airplane turns. Stop pull, turn stops. Immediately. The learning light goes on, hopefully someone else goes home with a little understanding of what makes the airplane fly.

I replied: You can pull the elevator without banking the wings and the airplane will not turn (at least in the traditional, heading change sense, although it will “turn” upward). You can bank the wings without pulling on the elevator (or adding power) and the airplane will probably begin to turn; banked too little and it will likely return to wings level out of longitudinal stability, i.e., stop the turn. But banked too much and it will probably enter a spiral, which includes a turn but is not usually considered to be a controlled maneuver. But to fly a controlled turn you must bank and pull (or bank and add enough power to increase lift). Right?

Well, yes and no. Lift is a product of angle of attack and airspeed. The lift vector is always at a right angle to the relative wind, on the lifting side of the wing. If you are wings level and pull straight back, the aircraft will indeed turn, but in the vertical plane, i.e. a loop. Tilt the lift vector by banking and the aircraft will turn horizontally, [the] rate depends on how much bank angle, but more importantly, how much total lift is available. If you bank and unload the wing to a zero-lift AOA, it will not turn. If you bank over 45 degrees, most of your lift is horizontal and the harder you pull the harder you turn.

But the kicker is, if you are using your lift vector to turn, you have less vertical lift to maintain altitude. So to stay level, you have to make the lift vector longer. Two ways to increase lift, increase AOA or go faster (or both). Generally we pull to increase AOA, but this will increase induced drag, so we need to add thrust to overcome this if we want to maintain constant airspeed, otherwise we slow down.

Next thing to consider: the harder we turn, the more we load the airframe. People commonly refer to this as centrifugal force but really this is a function of inertia, as Newton’s first law states, a body in motion will remain in motion unless acted upon by an external force. In this case, the aircraft is trying to go straight but the pilot is making it go elsewhere. Inertia results in effective increase in weight, i.e. G loading. An unaccelerated 60° banked turn, as you well know, results in a 2G load. A 3200 pound [airplane] now effectively weighs 6400 pounds and requires twice as much lift to maintain altitude. But if you pull harder, say 4Gs, we now need 12800 pounds of lift. Same bank angle, to maintain enough lift we have to increase AOA significantly or add a lot of thrust. Easy to do if you are flying an F-16, not so much in a Bonanza, let alone a 172. AOA is limited by critical alpha beyond which the wing will stall no matter how much thrust or speed we add.
My primary point (sorry for the pedantic epistle!) is that **lift and turning is poorly understood by most pilots.** If you understand lift, you will be unlikely to be involved in a stall-spin accident. My retirement mission is to get as many pilots to stay alive as possible. As of last week, I have signed off 34 CFI spin endorsements since moving my airplane to Florida last July. Hopefully they will go out and share some of this!

All true. But if the layman’s question is “how does an airplane turn?”, and you accept what he/she is actually saying is “How do I make the airplane’s heading change in a controllable manner while in level or near-level flight?”, then answer is it takes both bank and elevator to turn, and arguably the rudder as well (although an airplane can “turn” without being coordinated; lack of coordination just introduces undesirable stall characteristics). So as I summed up, without going into as much detail as you from your depth of experience, is **“it’s all interconnected.”** No one control input alone can make the airplane turn in the layman’s sense. Pitching is a turn along the lateral axis, but it is not “turning” in the context of this common question.

No argument on that. What I try to do is to get prospective CFIs to actually understand some aerodynamics on a little deeper level than most have been taught, so hopefully they will impart some of it to their future students. You and I both know that a lot of young (and not-so-young) instructors don’t really know much other than the minimum they got from the puppy-mill flight school being taught by recent graduates of the same place. You would be surprised how often I get asked, “How come nobody ever told me that?”

Since I no longer have a real job, I have plenty of time to ruminate on this stuff!

I’m glad you do, Tony, and that you’re willing to educate me (and by extension my readers) as well. A pilot can control an airplane very crudely, but flying crudely can be disastrous when precision is needed because of the circumstances. But to fly well, to attain maximum performance and efficiency, and to survive an emergency, you have to fly well. These are the times you need to have the level of understanding Tony imparts to his flight instructor students, and that I try to impress through these LESSONS.

The Wright Brothers are almost universally accepted as the first to successfully fly a heavier-than-air aircraft (there are always some dissenters). There were, however, others before them—Octave Chanute, Otto Lilienthal, Clemeet Ader, Hiram Maxim, Samuel Langley, and perhaps even Gustav Whitehead all flew gliders and/or powered aircraft or aircraft models in the years and decades before the Wrights. What we *should* call the Wright Brothers, to proclaim their true triumph, is the first to successfully make **sustained controlled flight** of a heavier-than-air aircraft.

Like those before them, the Wrights began their experiments understanding the need for yaw control, but assuming yaw is controlled with a fixed vertical surface—a stabilizer, not a rudder. When their early glider experiments proved that incorrect, they next invented a moveable rudder that was connected to lateral control (wing warping) so that a given amount of bank input automatically caused a constant, corresponding rudder input. This resulted in what the Wrights called **“well digging”—referring to the small crater left in the sand when the glider uncontrollably hit the ground. It was only when the Wrights made rudder control completely independent of inputs were they successful:**

After modifying the glider’s rudder, the Wrights now had a true three-dimensional system of control. This three-axis control system was their single-most important design breakthrough, and was the central aspect of the flying machine patent they later obtained. In its final form, the 1902 Wright glider was the world’s first fully controllable aircraft.

Inventing three-axis control was the brilliance of the Wright Brothers. All it took for them to make history was to apply their independent rudder system to a powered version of their gliders, then to complete their
experimental period by perfecting the aeroplane. Over a century later, we still sometimes struggle
with understanding precisely how to use the Wrights' triumph when we fly.

See:
https://airandspace.si.edu/exhibitions/wright-brothers/online/fly/1902/perfecting.cfm
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