Lesson 2: Steep Turns

Fly This Lesson Now

—by Rod Machado

I like steep turns! They're fun, challenging, and, in many cases, they are a good test of a pilot's ability to recognize the limits of airplane performance. And, if you play Microsoft® Combat Flight Simulator, they're useful to get away from a bandit who is trying to shoot your tail off!

Steep turns (those typically done between 45 and 55 degrees of bank) are used to develop flight proficiency. Practice them often, and you'll find yourself becoming smoother on the flight controls. Steep turns also help you learn to handle the natural division of attention that accompanies such a high-performance maneuver.

There's another benefit of which you may not be aware. Steep turns demonstrate that airplanes have limits and exceeding those limits has a cost. Making too steep a turn can result in a stall. This isn't necessarily dangerous if you're several thousand feet above the ground. However, don't try making a steep turn to align yourself with the runway when you're at a low altitude with insufficient airspeed. This is a sure-fire way to get into a new line of work, like geology. You'll really get into it—about six feet deep into it.

Steep Turn Aerodynamics

First, a little review: In an earlier lesson, you learned that banking the wings allows lift to pull the airplane sideways. The airplane turns because some of its lifting force acts in the horizontal direction.

Of course, once an object is set in motion, it wants to remain in motion. A fellow named Newton said that (that's Isaac, not Wayne). When an airplane turns, its entire mass still wants to maintain its original direction. That's why you feel yourself forced down in your seat on a roller coaster when the track changes direction. The roller coaster is changing directions, but your body wants to continue moving straight ahead. Coupled with the downward pull of the earth, you feel like you'll go right through the roller coaster's seat.

Although airplanes don't fly on tracks, you'll feel a similar force pulling you down in your seat when making a steep coordinated turn. The steeper the turn, the greater the seat-pulling force. This force is sometimes called the G-force (or load factor). The "g" in G-force is derived from the word "gravity" and has nothing to do with the sound passengers make when they feel themselves forced down in their seats during steep turns: "Gee!"

G-force is a predictable force for all airplanes. Figure 2-1 shows a graph representing the increase in G-force for a given bank.

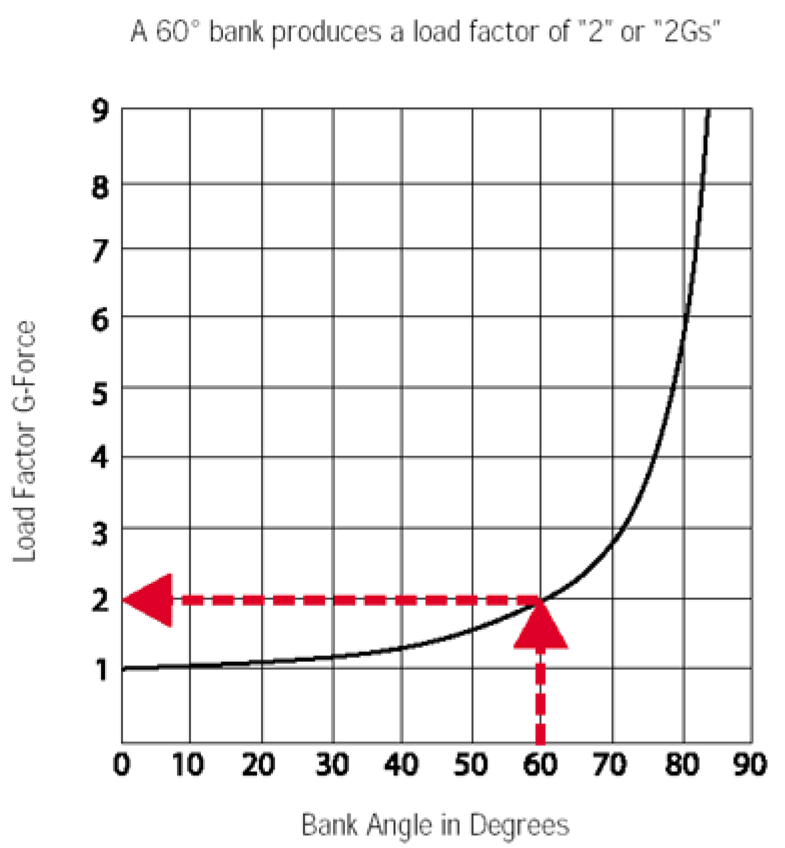

Figure 2-1 Load Factor chart

The example shows that in a 60-degree bank, you and the airplane will feel a G-force of 2 (two Gs). In other words, you and the airplane feel like you weigh twice as much as you normally do. Imagine that. You experience an apparent increase in weight, all without letting even one bag of greasy fries slip past those disciplined lips of yours. Of course, you can lose that weight by rolling out of the turn back into straight-and-level flight, where you'll feel a G-force of 1-just like you feel right now (which is determined by how many fries you've eaten up till this point in your life).

Here's the catch: If you and the airplane feel heavier because of an increase in G-force, then you, the pilot, must compensate for the artificial weight increase. You must increase the airplane's lift if it is to keep flying. Without compensating for this, the airplane won't be able to maintain altitude in a steep turn. In fact, it can even stall. And you don't want to become known as a pilot who stalls whenever he or she makes a steep turn. Imagine the kind of nickname you'd get for that: Imelda Impact, Steve Splatdown, or Chris Crater.

Increasing lift in a steep turn means that you must increase the angle of attack by applying back pressure on the joystick. Lift must equal weight—real weight or apparent weight—if the airplane is to remain flying. That's why steep banks require large angles of attack to produce the lift necessary for flight. You see what's coming, right?

If you make too steep a turn, the airplane may reach its critical angle of attack before producing sufficient lift for flight, and the airplane will stall. Now you're forced to recover from the stall before you can continue flying.

You've just learned that an airplane's stall speed increases in a steep turn. While you may stall at 50 knots in straight-and-level flight, you may need 70 knots to keep from stalling when turning steeply. Figure 2-2 is another graph, which allows you to predict this increase in stall speed based on an increase in G-force.

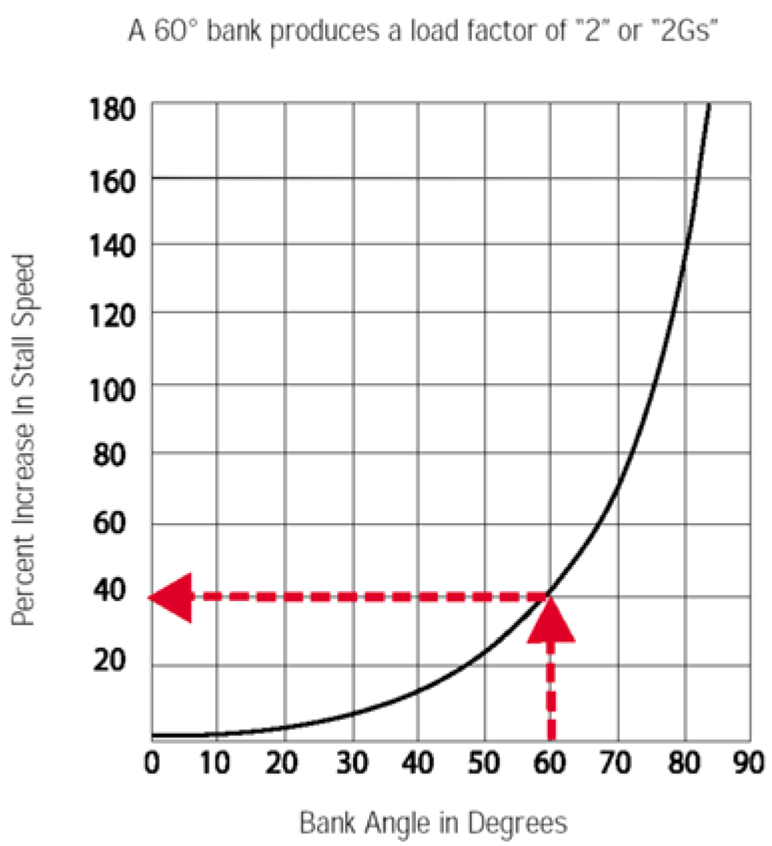

Figure 2-2 Stall speed and bank angle chart.

For example, in a 60-degree bank, the airplane and its contents experience 2 Gs (that's a G-force of 2). Figure 2-2 shows that 2 Gs give you a 40 percent increase in stall speed. Therefore, an airplane stalling at 50 knots in level flight will stall at 70 knots in a 60-degree bank (40 percent of 50 added to 50).

Here's what this means to you. If you're planning on doing a steep turn at 60 degrees of bank, you'd better have an airspeed of at least 70 knots if you want to avoid a stall. Isn't that amazing? You made a prediction and didn't need to peek at a magic crystal ball, throw bones, or read tea leaves (you can save these things for weather predictions).

That's why you'll need to add additional power when doing steep turns. In most cases, this provides the necessary increase in speed that helps prevent a stall. Of course, if your airplane doesn't have a big engine, then it may not be able to produce the thrust necessary to keep the speed high enough to prevent a stall during a steep turn. Well, I remember going to a doctor and saying, "Doctor, it hurts when I do this!" Her advice, of course, was "Don't do that."

If you don't have sufficient power, then you can't go around making really steep turns. And the author's decision is final on that.

Don't worry about technique right now. You want to examine the aerodynamics first, and then we'll talk about the art of making turns.

What This Means to You

It appears that you need a six-degree nose-up attitude to hold your altitude in this turn. Since your angle of attack increased, more of the wing's underside is exposed to the airstream. This creates more lift—but also more drag. Thus, the airplane slows down a bit, as shown on the airspeed indicator.

So, here's a problem for you:

- A steep turn with a constant altitude is accompanied by a decrease in airspeed.
- Coupled with an increase in stall speed, you may find yourself caught between the proverbial rock and a hard place if you're not careful.
- As the stall speed increases and the airspeed decreases, the two may eventually meet.

What happens then? Yes, the airplane stalls. How might you prevent this in a steep turn? Try adding power to prevent airspeed loss. Once again, don't worry about making beautiful steep turns yet; ugly ducklings are fine for right now. Hack your way through it, and I'll teach you the proper steps to the dance in a bit.

Two G or Not To G

Suppose you roll into a 45-degree bank and add full power. What will happen? You'll notice that the increase in power allows the airplane to maintain its airspeed. There you have it. A nice steep turn without a decrease in airspeed is possible as long as you have sufficient power. But suppose the turn is really steep? Let's say it's at 60 degrees of bank. At this bank angle, your stall speed increases from 50 knots to 70 knots. The question is, "Do you have enough power to keep the airspeed above 70 knots in a 60-degree bank turn?" The only way to find out is to try and experiment with this at a safe altitude. When you do this experiment, you'll find that the airspeed will decrease, even with full power. Why? Because small airplanes just don't have the extra power to overcome the enormous increase in drag associated with the required increase in angle of attack.

The Tough Part

Here's where pilots often get themselves into trouble. When maneuvering for landing with power at idle, they make steep turns to align themselves with the runway. Given their slow speed and steep bank, the airspeed and stall speed converge. In other words, while in a steep turn, the stall speed increases because of increasing G-force and the airspeed decreases because of increasing drag. When the airspeed and stall speed meet, the airplane stalls. If this happens close to the ground, it's a really bad deal. You'll often hear this type of stall called an accelerated stall. It's accelerated because of the high G-force caused by a steep turn.

Okay, enough science, Mr. Spock. Time for artistry. Let's talk about how to make classy steep turns.

A Touch of Class Before You're Out of Gas

One secret to making a good steep turn is to have a predetermined idea of the attitude necessary to hold altitude in that turn. While there are many variables affecting this, you can still approximate it. Normally, you'd also use outside visual references while doing steep turns in an airplane. This allows you to keep a lookout for other airplanes, as well as identify the airplane's attitude. Using outside visual references for steep turns, however, is a little tough to do in a simulator, so you'll focus on the attitude indicator instead.

Take a look at Figure 2-3.

Figure 2-3

This is the approximate attitude necessary for a turn at 45 degrees of bank. As you roll into the turn, you'll need to progressively increase the pitch until you reach a 6-degree nose-up attitude. Then, you should use the altimeter to determine what type of small pitch correction is necessary to hold altitude. You can also use the VSI as an additional source of information, if you like. The secret is to make small corrections and always keep an eye on your attitude.

Overcorrection is sure to send you wandering all over the sky as you try returning to your assigned altitude. A steep turn is considered acceptable by private pilot standards when the following things are all true:

- Your altitude doesn't vary more than 100 feet.
- The heading on rollout is within 10 degrees of the direction you started with.
- The bank varies no more than 5 degrees.
- The airspeed remains within 10 knots of the entry speed.

There's one other thing you should be aware of when doing steep turns. Pulling back on the joystick tends to increase the bank a little. That's why you must be careful not to let the bank increase during a steep turn. This is a rather common occurrence when applying back pressure on the joystick. Additionally, at steep bank angles, airplanes have a natural tendency to steepen their bank without the pilot doing anything to cause this. Once again, be prepared to compensate for this with aileron pressure if necessary. Therefore, in a steep turn, especially when applying back pressure to maintain altitude, you might need to apply a little opposite aileron with the joystick to prevent overbanking.

Perhaps you're wondering why I haven't mentioned anything about trimming during the steep turn. The reason is that we only use trim to hold the controls in one place for a relatively long period of time. Since steep turns are transitory, trim isn't normally used. Besides, steep turns help you to recognize the onset of an accelerated stall. In the actual airplane, you can feel yourself being forced down in the seat by increasing G-force. You can't feel this in a simulator. Therefore, you must rely on the back pressure you're applying to the joystick to warn you of an approaching stall at higher airspeeds. This is another good reason not to trim in steep turns.

You're now qualified to try steep turns at larger banks. When you practice them in the Interactive Lesson, go all the way to 55 degrees, which is the bank required for commercial license certification. Roll into and out of the turns while holding altitude within 100 feet, airspeed within 10 knots, and rollout headings within 10 degrees of the entry direction. Have as much fun as you can!

It's time for you to practice steep turns. Click the **Fly This Lesson Now** link to practice what you just learned.

In the next ground school session, I'll show you how to keep your traffic pattern at an airport from becoming a tragic pattern.

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