PilotWorkshops Audio with

Rod Machado

TRANSCRIPT

#1 STICK AND RUDDER MUTTER

The following is a transcript from the monthly audio program featuring Rod Machado. This program is presented by PilotWorkshops.com, LLC.

Table of Contents

Introduction	3
The Accidents	4
A Pilot's Inability to Fly the Machine	5
What Stick and Rudder Flying Actually Means	6
How Stick and Rudder Pilots Fly Their Airplanes	6
How to Enter and Exit a Turn	8
Using Rudder When Established in the Turn	9
A Good Exercise to Develop Coordination Skills	12
So How Good Are You?	13
Visually Assessing Your Angle of Attack	18

Introduction

Greetings folks, this is Rod Machado. Welcome to my monthly audio aviation learning series here on PilotWorkshops. What I hope to do in these monthly programs is to provide you with some of the insights I've learned over 43 years of flying small airplanes. During that time, one of the most important lessons I've learned is that a pilot can be about as safe as he or she wants to be in the air. No, fate is not the hunter here. The fact is that many pilots have flown safely for decades and not because they've tapped into a plentiful supply of rabbit's feet or four leaf clovers. Flying safely is a choice. It's a choice based on several factors, not the least of which is understanding how an airplane flies and how to fly it safely. And that's the topic of this month's discussion.

So let's begin with an excerpt of a classic aviation book titled, *Stick and rudder* by Wolfgang Langewiesche. In his book, Mr. Langewiesche says something about the airplane's rudder that might surprise you. In the first paragraph of Chapter 11, he states:

The important thing to understand about the rudder pedals is that they are unnecessary; like your wisdom teeth, they serve no very good purpose but can cause much trouble. The airplane needs no rudder pedals. It should have no rudder pedals. In all probability it will have no rudder pedals 10 years hence.

Well, Mr. Langewiesche got almost everything right, but he didn't get that one right. And it's understandable why he didn't. In 1942, when *Stick and Rudder* was published, it was thought that all airplanes would eventually evolve in the form of Fred Weick's Ercoupe. The original Ercoupe didn't have rudder pedals. They were unnecessary on this machine because the airplane had the rudder and ailerons interconnected, allowing the displacement of one control to simultaneously displace the other, thus keeping the controls coordinated in flight. So Mr. Langewiesche was correct in assuming that, by 1952, the only airplanes we'd see flying around wouldn't need rudder pedals, but they would have mechanically interconnected rudder and ailerons.

Well, today many airplanes do indeed have their rudder and ailerons interconnected by a spring or a bungee cord system, but they still have rudder pedals. It turns out that if you want to have complete control of your airplane, you need rudder pedals to do it. While you might be able to land an Ercoupe in a crabbed condition during a reasonable crosswind, you shouldn't plan on doing the same thing in your modern tricycle-geared airplane. The airplane and the gear typically aren't designed for this. Therefore, you need to use your rudder to either straighten the airplane out for landing or to align the longitudinal axis with the centerline while banking to correct for drift.

The fact is that rudders are here to stay, and this makes Langewiesche's statement that they can cause much trouble, especially significant. A pilot who doesn't know how to use his or her rudder, is like a kung-fu master without much fu. So let me ask you a few questions.

Do you have good stick and rudder skills? Are you sure you even know what it means to have these skills? And why is it necessary to have these skills when flying today's higher performance, technically advanced airplanes?

The fact is that a pilot's inability to control his or her airplane has become a hot topic over the past few years, especially given the many high profile cases that implicate a pilot's lack of flying skills as the root cause of many aviation accidents. Well, that's the topic of discussion for this month's audio presentation. So buckle up, strap in and hold on for a look at what it means when a pilot is or is not in control of the machine he or she flies.

The Accidents

Our story begins a few years ago during a daylight flight in visual meteorological conditions (or VMC) when the pilot of a Cirrus aircraft managed to turn his airplane into the aerodynamic equivalent of a manhole cover in the traffic pattern of a busy airport. According to the NTSB report, the SR20 entered the traffic pattern followed by the tower controller's instruction to let him know when he (the pilot) had visual contact with another airplane on a one-mile final for the runway. At this point, the Cirrus pilot replied that he was on a "real short base" for the same runway. The controller, realizing that spacing was an issue, instructed the Cirrus pilot to "cut it in tight" to the runway. Well, that's just what the pilot did, and crashed as a result. Several witnesses described the airplane as entering a steep bank which was followed by a vertical, uncontrolled descent. The airplane disappeared from view into wooded terrain short of runway.

Yes, the airplane had sufficient fuel and there was nothing wrong with its structure or its engine. The pilot even appeared to activate the airframe parachute system, but did so at too low an altitude for satisfactory deployment.

So what happened here?

It's quite clear that the pilot stalled, then possibly spun his airplane. No doubt about it, he shouldn't have let himself be negatively influenced by the controller's assertion to "Cut it in tight," regarding his turn to final approach. But let's also remember that the controller didn't use a Jedi mind trick to compel the pilot to behave irrationally with his airplane, either. The controller's words have no direct connection to a pilot's yoke...well, at least they shouldn't. But this isn't the main issue here. The big issue here is that one of our fellow pilots had insufficient stick and rudder skills to fly his airplane safely, and he paid for his deficiency with his and his passenger's lives.

Most likely the Cirrus pilot increased his bank angle, pulled aft on the stick and, when the turn became excessively steep, he used opposite aileron in an attempt to decrease the angle of bank. This induced a yawing motion, resulting in a speed and angle of attack differential between the wings. When the airplane stalled, one wing reached its critical angle of attack before the other, and the airplane spun. Unfortunately, this isn't an isolated story.

A Pilot's Inability to Fly the Machine

There are many general accidents whose main cause seems to lie with a pilot's inability to fly his or her machine. A quick review of the accident data suggests, at a minimum, that a lack of basic flying skills is responsible for at least 40% of our current aviation accidents. But that's just for those accidents occurring in VMC conditions. In fact, my quick perusal of a recent year's worth of Cirrus accidents indicates that at least 46% were pure stick and rudder accidents occurring in VMC. Holy smoking cow!

This, of course, says nothing about the IFR pilot whose superior navigation skill allows him to travel hundreds of miles in instrument meteorological conditions, only to find that he can't keep himself from being blown off the runway in a strong crosswind. I'm sure this makes some pilots wish that their autopilots had a software plug-in with a name like, "Runway Centerline Finder."

To further support the idea that some pilots lack basic flying skills, let's take a peek at the results of a recent study known as the *Human Factor Analysis and Classification System* or HFACS for people who need to breath in order to live. This governmental supported study indicated that—and hold on here, you're not going to believe this—that, 84% of all accidents are skill-based accidents.

Now, to be clear about this, the HFACS study classifies "skill based errors" as those resulting from poor flying technique, failures in memory or failures in attention. These errors include basic feet and hand flying skills, but might also include the inattention and/or distraction that comes from focusing on a runway centerline that's just swooped past you as you tighten your turn to final while remaining completely unaware of an increase in load factor or of the elevator control drawn aft to nearly it's full length of travel. (And these, including several other indications, are clues notifying you that your airplane is about ready to enter stall/spin city). The point here is that while 84 out of 100 accidents might not be strictly stick and rudder in origin, it's clear from additional data that nearly half of all general aviation accidents are.

What Stick and Rudder Flying Actually Means

Now that you have a pretty clear idea about how a pilot's inability to properly fly his or her airplane is causing him to lose control of that machine, let's be clear about what we're actually talking about when speak of stick and rudder skills.

Not too long ago I was sitting with the president of a major aviation training company when he asked me, "Rod, what do you mean when you refer to stick and rudder skills?" That's a good question, because we assume that the definition is self-evident. Unfortunately, it's not, because the term, until recently, has managed to nearly disappear from the aviation lexicon. It has been replaced by the term *flight management skills,* which best represents the educational trend our industry has taken over the past several decades. So let me offer a definition for two types of pilots operating in visual meteorological conditions. The first one we'll call a *stick and rudder pilot* and the second one we'll call a *panel pilot*.

A *stick and rudder pilot* is defined as someone who flies his or her airplane primarily by looking outside the cockpit and paying attention to the physical sensations of flight. A *panel pilot*, however, flies primarily by referencing the airspeed indicator, attitude indicator and inclinometer and pays very little attention to the physical sensations of flight.

For example, when turning from base to final approach, a stick and rudder pilot estimates his proximity to the stall/spin condition by using sight (specifically, his attitude and wing chord line relative to airplane motion), then sound (the sounds associated with higher angles of attack) and finally feel (the pressure he feels on the flight controls, the control's responsiveness and any increase in load factor he feels). He primarily evaluates his use of rudder by examining whether or not the airplane's nose points in the direction the airplane turns, and by the uneven pressure distribution on his derriere.

On the other hand, a panel pilot evaluates his proximity to a stall primarily by looking at his airspeed reading and activation of the stall light/horn. If he uses rudder, he evaluates its use by looking at the ball in the inclinometer. He often fails to notice and respond to any uneven pressure on his derriere or sensation of increased g-loading and he considers himself immune from a stall if the nose is pointed below the horizon. Unfortunately, believing that you are immune from a stall because the nose points below the horizon is like believing that Washington D. C. runs on batteries. As you'll hear later in this program, this just isn't true.

How Stick and Rudder Pilots Fly Their Airplanes

Now that you understand the difference between stick and rudder flying and panel flying, let's talk about how stick and rudder pilots fly their airplanes. And we'll begin with one of the most important questions that anyone could ask you about your airplane's flight controls. "What's the purpose of your rudder pedals?"

Hopefully you didn't respond by saying, "Rudder pedals? What are these rudder pedals of which you speak?"

The answer is: in flight, the rudder pedals allow you to point the airplane's nose in the direction of your turn. That's right. That's what the rudder pedals do. There's only one occasion where you want the nose to point in a direction opposite the direction the airplane wants to turn and that's when you're slipping. No, not mentally slipping, either. I mean when performing a forward or a side slip, which we'll cover at a later time (I know, I'm such a tease, a slip-tease as a matter of fact).

Since we put rudder pedals on an airplane to help the nose point in the direction the airplane turns, this implies that there are times when the nose wants to point in a direction other than the direction the airplane is banked. How could that happen? Let me explain.

We roll an airplane into a bank using our yoke to deflect the ailerons. When entering a right turn, for instance, the right wing aileron deflects upward and the left wing aileron deflects downward. The lift on the right wing decreases and that wing moves downward while the lift on the left wing increases and it moves upward. And, unless you're flying a rubber airplane over a hot desert, it goes without saying that both wings alternately move up or down simultaneously.

But here's the rub. In basic aerodynamics, you learned that when you increase lift, you also pay a penalty with an increase in drag. There's no way of getting around this unless you tell me you're a Jedi Knight, but I know you're only human. Ahh! Don't deny it.

The wing that goes up—the wing on the outside of any turn—always creates a bit more drag. Therefore, the creation of lift sufficient to raise the outside wing will always create some drag that adversely yaws the airplane's nose to the outside of the turn. The airplane's natural response to rotating the yoke right or left, is for the nose to yaw in the opposite direction of turn. This response is called, "Adverse Yaw." And, at this point I want you to stick your left finger in your ear. Go ahead, do it. Do it. Because what I'm about to say is so important that I don't want it to go in one ear and out the other. Adverse yaw is always present any time the ailerons are moved from their neutral or centered position. In other words, when the ailerons are deflected, adverse yaw moves the nose opposite the direction you want to turn. The only time this isn't true is when the airplane has yaw dampers. And the only yaw dampers we have on our smaller airplanes are sticking out the bottom of your pants. That's right. They're called your "feet."

So when I asked you, "What's the purpose of your rudder pedals?" you learned that they keep the nose pointed in the direction the airplane turns. That's why every turn entry and turn rollout that requires deflection of the ailerons also requires the simultaneous deflection of the rudder pedals to compensate for adverse yaw. Yes, there are a few exceptions to this that involve engine power and we'll cover these shortly (even if you aren't wearing shorts).

How to Enter and Exit a Turn

Now the big question is: When you roll into or out of a turn, how do you know how much pressure to apply to the rudder pedal to keep the turn entry coordinated? Did I hear you say that you look at the ball in the inclinometer? You said it, didn't you? OK, you thought it. Ahh haa. Don't deny it. Well, that's how a panel pilot determines the amount of rudder to use when entering or exiting a turn. The fact is that the inclinometer isn't very accurate when entering or exiting a turn. There are several reasons for this, one of which is the instrument's location on the panel as well as the ball's inertia and the liquid in its travel tube that dampens its motion. This is why the ball can lag in response to control inputs or, in a very temporary way, improperly represent the coordination of your control inputs. Once a turn is established and stabilized, however, then this is no longer an issue and the inclinometer is generally quite accurate.

So how do stick and rudder pilots determine the amount of rudder to use when entering or exiting a turn? They simply look directly ahead of them over the panel, at a point directly above the center of their seated position, then roll right or left while simultaneously applying just enough rudder pressure to keep the nose from yawing in the opposite direction of turn. That's right. It's a visual thing. No inclinometer needed.

As the airplane rolls at a moderate rate about its longitudinal axis into the turn, the nose appears to remain stationary until a moderate bank is reached. I know that this might seem strange, but this is actually how it appears to you. Yes, the nose begins to move in the direction of bank as the airplane overcomes its inertia and begins to turn. But, because of this inertia, the nose actually *appears* to remain stationary during the roll in. Your job is to apply enough rudder pressure to keep the nose from yawing opposite the direction of roll. Doing so means that your roll is coordinated. This is how you roll into a turn.

Now, I'll talk about how stick and rudder pilots use the ailerons and rudders once the turn is established, shortly. Right now, however, I have a more pressing question for you and it has nothing to do with the wrinkles I see in your shirt. Oops, you aren't wearing a shirt are you? My apologies. My question is, "When you roll out of a turn, how do you know how much rudder pressure to apply to keep rollout coordinated?" Did you say, "The inclinometer?" Actually, you use the same method you used when rolling into a turn. When you reach the point of the turn where you desire to rollout, you simply apply aileron in the direction you want to roll and use sufficient rudder to keep the nose from yawing opposite the direction of roll.

In other words, if you're established in a right turn and want to roll into wings-level flight, you'll simultaneously apply left aileron and sufficient left rudder pressure to keep the nose from yawing to the right (opposite the direction of roll) during the rollout. As a practical matter, as you begin the rollout, the nose should appear to remain stationary if the proper amount of rudder is used. This is how stick and rudder pilots roll into and out of turns using their yoke and pedals in coordination. They don't look at the inclinometer to accomplish this task. They look outside, which is good because this is where a pilot should be looking 90% or more of the time when he or she is not flying in instrument meteorological conditions.

Using Rudder When Established in the Turn

Now that you know how to roll into or out of a turn with the coordinated use of ailerons and rudders, how do you keep the turn coordinated once it's established? And don't worry if you didn't get these questions correct. I grade on a curve, which, by the way, is exactly what the airplane does when it turns. It makes a curve.

As the airplane turns along a curving path, it is flying coordinated if its nose is pointed in the same direction of that path. Now, unless you are deflecting the ailerons to maintain a specific bank angle (such as a steep bank) and unless the airplane's power-induced left turning tendencies are attempting to yaw the airplane to the left, you typically don't need to apply any rudder pressure to keep the turn coordinated. That's right. The airplane's built-in yaw stability keeps the nose pointed in the direction of turn. This is, after all, why your airplane has a vertical stabilizer which is the non-moving vertical part of the tail complex.

Nevertheless, the airplane can be uncoordinated in a turn in that it can be slipping or skidding (Not to worry. I'll explain these terms in detail shortly). So how would you know the turn is uncoordinated once it's established? Well, there are three ways you can tell.

First, you can look at the inclinometer and see if the ball is deflected. Technically speaking, a turn is coordinated if the ball is displaced less than ¼ of its width. When I was a student pilot, this is one reason I always preferred to fly airplanes having tiny little inclinometers. It's simply harder to see how much the ball is deflected if the ball is tiny to begin with. Unfortunately, as a student pilot, my instructor said I should be on the cover of Rolling Stone magazine because that's what the solid black ball in the inclinometer always did when I flew with him. It rolled back and forth and back and forth in its glass container. Now I know what he meant when he kept mumbling, "Pilots who live with glass housings shouldn't roll stones."

No doubt you've heard the phrase "Step on the ball" at one time or another in your training. Well, this is where it's applied. For instance, if you're in a right turn but the nose points to the outside of the turn arc, then the pair of sunglasses you have on the panel will slip to the right, toward the inside of the turn. The ball in the inclinometer will also slip to the right because you're in a slipping turn. In this instance, the nose is trying to turn slower than the airplane turns, and you need to speed the nose up. So add a little right rudder—in the same direction the ball has deflected—to point the nose in the direction of turn.

On the other hand (or other foot, if you will), if you're in a right turn and the nose points to the inside of the turn arc, then the pair of sunglasses you have on the panel will skid to the left, toward the outside of the turn. The ball in the inclinometer will also skid to the left because you're in a skidding turn. In this instance, the nose is trying to turn faster than the airplane turns and you need to slow the nose down a bit. So add a little left rudder—in the same direction the ball has deflected—to point the nose in the direction of the turn.

As I mentioned earlier, looking at the ball to identify when you're flying coordinated is how panel pilots fly. You're a stick and rudder pilot, so the "ball" method should be your least favorite means of evaluating flight coordination. Fortunately, there's actually a better method for doing this.

The second way to know if you're flying coordinated once established in a turn is to look over the nose and see if it actually points along the curving flight path made by the airplane. In extreme cases of uncoordinated flight, you can easily see the nose pointed outside or inside this curving path of the airplane. Yes, this works at all altitudes where you can see the ground, but it tends not to work too well close to the ground in gale-type winds. Then again, if you're out on a pleasure flight during a hurricane and find yourself crossing time zones faster than you can update your watch, then control coordination is probably the least of your concerns.

For example, one instance where you might easily see a difference between where the nose points and the airplane's flight path occurs immediately after liftoff if you begin a right climbing turn without adding sufficient right rudder. The airplane's power induced left turning tendencies, resulting mostly from propeller slipstream and P-factor, yaw the nose to the left of the right curving flight path.

We call this a slipping turn since the nose points to the outside of the turn arc. This should be obvious to you as long as you're not wearing Foggles, a hood or a welding mask. Then again, you shouldn't be welding in flight, but we should always have respect for our welders, nevertheless. In this instance, you'd need to apply right rudder pressure to point the nose in the direction of the turn.

On the other hand, imagine that you are making a descending left turn from base onto final approach and are about to roll the airplane to wings-level flight on final. Here is where many pilots fail to use their rudder pedals properly to keep the rollout coordinated, and the only acceptable excuse for doing so is if their legs have been simultaneously hit by dual Macusi Indian paralyzing blow darts. As they roll right to wings level flight, adverse yaw from the lowered aileron on the left (rising) wing yaws the nose to the left of the now straight flight path, resulting in a skid, with the inclinometer's ball deflected to the right. As the nose yaws to the left with the application of right aileron, you should counter this by immediately adding right rudder to stop the nose movement, thus keeping the rollout coordinated.

Finally, the third way is, ultimately, the preferred method used by stick and rudder pilots to coordinate their turns, but it is one that takes a bit of practice to develop. I'm speaking of flying by the seat of your pants, assuming of course that you wear your pants when you fly. And I recommend it, especially on checkrides...especially if you want to pass.

Here's how this method works. During a slip or skid, the inclinometer's ball will deflect to the inside or the outside of the turn, respectively. As this happens, the force responsible for deflecting the ball also deflects your derriere, too. Of course, your derriere is much more massive than the little inclinometer's ball. Wait. Wait. Come back here. I don't mean anything personal by this. I mean massive in "comparison." So please don't report me to the Jenny Craig sensitivity police here.

In a slipping or skidding turn, you'll feel a slight displacement on one side of your rear end and this is your clue that you need to add rudder to keep your rear end centered in its seat. The rule is: step on the ball or step on the cheek. If you feel pressure on your right cheek, then you need to apply a little right rudder to equalize pressure between the cheeks.

Yes, it does take a bit of time to recognize and become sensitive to the uneven forces applied to your rear end. This process, however, is sped up when you use a little feedback. And here is where the inclinometer's ball really serves a useful purpose when you're established in a turn. You might even say that it becomes a means of cheek checking.

To help you develop a sensitivity to this uneven pressure, the next time you're making turns, glance at the ball. If it's deflected to the right or left, then attempt to detect the uneven pressure on your derriere. Try to connect that uneven pressure with one of your cheeks then notice how that pressure disappears as you add right or left rudder, respectively, to center the ball. The "detect, connect and cheek check" method is how you develop the necessary sensitivity to know whether or not you're flying coordinated solely by the seat of your pants. It usually takes a pilot about 30 hours of flight experience to develop this sensitivity. And, with continued practice, you'll be amazed at how sensitive your derrière will become. Yes, practice is essential here. So let's look at a few tools that can help you develop your stick and rudder coordination skills.

A Good Exercise to Develop Coordination Skills

One of my favorite methods of developing rudder and aileron coordination skills is known as a *coordination roll*. Pilots sometimes refer to this as a Dutch roll, but this is a misnomer. And no, a Dutch roll isn't something caused by wearing wooden shoes when you fly. A Dutch roll is actually an unstable behavior typically associated with swept wing airplanes and it's not what we're discussing here. What I'm talking about is a maneuver where you point the airplane's nose at some outside reference and roll right and left with a moderate bank while keeping the rudder and aileron coordinated. How do you know your flight controls are coordinated? Because the airplane's nose doesn't move as it rolls alternately between right and left banking conditions. Here's how it's done.

With the nose pointed to some outside reference while in level flight, roll to the right and add just enough right rudder to keep the nose fixed on the reference point. This is exactly how you enter a coordinated turn to the right, correct? When you reach approximately 30 degrees of bank immediately roll the airplane to the left. This means the moment you apply left aileron to begin the roll, you'll need to apply just enough left rudder to keep the nose straight as you roll.

Now, what I don't want you to do is to look at the ball in the inclinometer during this maneuver. Why? Because there's no telling what the ball is doing. In some airplanes the ball might remain nearly centered. The Cessna 150 is such an airplane. Try this in a Remos, and the ball will be banging up against each side of the inclinometer's glass tube during a perfectly coordinated coordination roll. It will sound like you left the airplane's turn signal on...opps, sorry, that only happens in a flying car. As I mentioned earlier, the inclinometer doesn't necessarily reflect the quality of your turn during the entry, compared to when the turn is established. So don't look at it during this exercise.

The coordination roll is an excellent training exercise and it's one I use quite frequently with pilots during their biennial flight review. If you can keep the nose steady on the reference point during this maneuver, then you've definitely got game—rudder and aileron game, that is.

At this point, you should have a very clear idea about how pilots with good coordination skills fly their airplanes, at least when making turn. But what about maneuvering in general? How do skillful pilots maneuver their airplanes in climbs, turns and descents? Well, let's find out.

So How Good Are You?

One of the ways I can immediately tell how good a stick and rudder pilot you are is by having you perform one of the most challenging maneuvers in aviation. Yes, it's actually that challenging, but deceptively so. If you don't have the skill set I'm presenting here, then acquiring it should be your goal. Here's how it works.

Once we're in the practice area, I'll reach over and cover up five of your main panel instruments leaving only the altimeter or altimeter tape in view. As I place my no-peekie round covers over the instruments, you will, of course, attempt to remove them by distracting me, perhaps by pointing to the floorboard and saying something like, "Oh look, cheeseburger." Unfortunately, this simple distraction works on 9 out of 10 instructors having weak minds. Of course, once I stop looking for the burger and overcome my disappointment, those no-peekies are going back on, pal.

Next, I'll ask you to enter slow flight at minimum controllable airspeed (or MCA) just above stall with the airplane in its clean configuration while holding altitude. If you're good on the flight controls, you'll pull that throttle back to flight idle (or nearly so) and simultaneously apply elevator back pressure to maintain altitude. When you are a few knots above stall (identified by the stall horn, stall light or pre-stall buffet), you'll immediately move that throttle forward without dallying, delaying, dabbling, dribbling or babbling. And when I say, "movement" I mean actual movement, not "I'm gettin' around to it" movement, or "I'm thinkin' about it" movement, I mean "Quickdraw McGraw" movement. This is one time you can't be timid with your throttle and hope to hold your altitude, because your altimeter needle is going to unwind so fast that it's likely to fly off and knock the cheeseburger out of your instructor's hands.

As the power increases, you'll simultaneously press on the right rudder pedal knowing that the entire universe (specifically the airplane's power induced left turning tendencies) is doing everything possible to yaw the airplane's nose to the left. But you'll have none of this nonsense because you are in command of your airplane, right? Right! So step on that right rudder pedal.

Finally, you'll grab a handful of trim wheel and spin it downward in a no-nonsense move reminiscent of famed Wheel of Fortune's Vanna White "hopped up" on a Starbuck's espresso. That, my friend, is how a good pilot enters slow flight at MCA with the airplane just hanging on the edge of a stall. But wait, the challenge is on, and the game has just begun.

To further test your skills, I'll ask you to make a moderate banked turn to the right at MCA. If I see you begin the turn by adding a lot more power while simultaneously adding a very tiny amount of right aileron followed by a lot—and I do mean a lot—of right rudder, then I'll know you have exceptional stick and rudder skills.

At this point, and while still turning, I'll have you begin a power-off descent at MCA while keeping the airplane in a moderate bank. If I see you lower the nose to maintain MCA while simultaneously reducing right rudder pressure, then I'll probably fall out of the airplane from shock at such a demonstration of skill. It's rare to find someone other than a flight instructor with this type of flying skill.

If you can do these things, then the game is over and you win big time. Very impressive. If you can't do this, then this level of skill should be your goal. This, after all, is something that many pilots have great difficulty doing, but not good stick and rudder pilots. In fact, here's what happened when a good stick and rudder instructor asked a Cessna 210 pilot to do the same maneuver during a flight review.

The instructor said, *"I checked out an owner/pilot of a C-210 who had flown hundreds of hours in a Cherokee six. During our first flight I asked him to demonstrate slow flight at 90 knots. We did a full 360 degree turn before he could set up the airplane in a clean configuration at 90 knots. I asked this particular fellow to practice descents using pitch to control his airspeed and power to control rate of descent. His answer was how can I do that if throttle controls my speed? I know this can happen to many pilots. The surprising part is that his instructor praised him as being one of his best students... that was just jaw dropping. Needless to say, when we practiced a "dirty" stall we entered the incipient part of a spin before I had to take over."*

OK, I'm back. So the question is, "What additional skills do you need to be able to fly as good stick and rudder pilots do?" Well, the one thing you absolutely must understand is the concept of *angle of attack*. It's simply impossible to fly well without this concept firmly established in the folds of that mighty head resting on top your shoulders.

Let's test your understanding of this concept with a question. If you're in an airplane performing a high "positive G" loop, what happens to the angle of attack when the airplane goes inverted at the top of the loop? Is the angle of attack zero, or is it a negative value or a positive value? Well, if you maintain positive G's throughout the loop as you should do, unless you have loopy skills, the airplane's angle of attack will always be a positive value. A positive angle of attack value means that the airplane is developing lift that pulls the airplane in a direction from your feet to your head as you sit in the cockpit. When lift pulls in this direction, it doesn't matter whether you're inverted on not because you will always be forced into your seat as a result. Since you are, indeed, forced into your airplane seat at the top of a high positive G loop, it should be clear that the angle of attack is a positive value throughout the entire loop. So think of this as an example of the man keeping you down—down in your seat that is. And the man of which I speak is Sir Isaac Newton since he was the first to formularize the idea of force that I just mentioned.

With that idea in hand, or in mind, let's see how we can determine our angle of attack during flight without the use of an angle of attack indicator. This is an important idea to understand because the airplane's wings will stall when the angle of attack reaches its critical value, which is approximately 18 degrees on the average airplane. Of course, good stick and rudder pilots never accidentally stall their airplanes. Never! The reason they don't is because they have several different ways of determining their angle of attack. These are the secrets I want you to learn.

During cruise flight the airplane flies approximately level with the horizon, but that doesn't mean the wings do. Remember from private pilot ground school that the wings are attached to a level airframe at an angle of approximately four degrees. This angle is known as the *angle of incidence*, which allows the fuselage and its passengers to fly level, or sit perpendicular to the ground, which is a comfortable position, while the wings' four degree angle of attack provides the necessary lift for cruise speed flight. By slowing down in straight and level flight, any increase in pitch attitude is a direct reflection of your increasing angle of attack.

So let's enter slow flight in straight and level flight and raise the nose to 14 degrees on your attitude indicator. Now the airplane's angle of attack is approximately 18 degrees, or close to the critical angle of attack (remember, at 14 degrees nose up attitude, your wings are still angled four degrees above this). So it's easy to roughly estimate your angle of attack in straight and level flight by evaluating the airplane's attitude. Unfortunately, straight level flight is the only place you can use your attitude indicator to make this assessment. Once the airplane enters a climb or a descent, this method no longer works because your flight path is no longer parallel to the earth. In fact, it's angled either up or down, making an estimate of angle of attack a bit more challenging.

For instance, when established in a climb, the airplane's flight path is inclined with respect to the horizon. But you don't know how much it's inclined. For example, assume you're in a P51 and your climb path is angled steeply with the horizon. The nose is pointed up quite steeply since you have a lot of power available to you. In fact, your attitude indicator might indicate a nose up pitch attitude of 40 degrees. But the angle between the wings' chord line and the relative wind generated by your flight path is most likely only 11 degrees. If, however, you're climbing in a Cessna 150 (which is what you do most of the time in a Cessna 150), your climb path is probably not very steep at all. In fact, your attitude indicator might only show a 15 degree nose up attitude. And let's be frank here, the closest the word "steep" pertains to your flight path occurs only if you're making in-flight tea. The angle between the wings' chord line and the relative wind, however, is most likely 11 degrees. The lesson here is that during a climb, your attitude indicator is of no use in helping you estimate your angle of attack during a climb.

The same idea applies to descending. You also don't know the angle at which you're descending. This is especially true when you consider that some airplanes might descend with a relatively shallow glide angle while others descend with the glide profile of a manhole cover. Once again, all bets are off for using your attitude indicator to estimate your angle of attack in a climb or descent. So how do stick and rudder pilots think about their angle of attack during a climb or descent? The answer might surprise you.

The one thing that really concerns these pilots about their angle of attack is that it remain below the critical angle of attack, because the airplane's wings simply won't stall if they don't exceed this angle. Period. It's not going to happen. These pilots don't get all excited about the angle of attack at which they're climbing or descending as long as that angle of attack remains below 18 degrees. This is easier to understand when you consider that most climbs and most initial approaches are made at an angle of attack whose value is located somewhere between a cruise angle of attack and the stall angle of attack, which is to say, somewhere between 4 degrees and 18 degrees, or somewhere near 11 degrees (perhaps even a little bit higher, but this value will work for our purposes).

After all, you typically climb somewhere around the best rate of climb speed, or Vy, which occurs at an angle of attack somewhere around 11 degrees. And, not surprisingly, you typically fly your *initial* approach in the pattern at a speed that's also not that far away from the best rate of climb speed. As an interesting aside, we typically use a slower speed with flaps on final for a steeper glide angle in the same way we use a speed slower than Vy during a climb to give us a steeper climb angle, also known as the best angle of climb speed. And it's true that we're closer to the critical angle of attack at these slower speeds. Nevertheless, the takeaway point here is to understand that stick and rudder pilots don't fret over the wings' angle of attack until it approaches the critical value.

Now, not fretting over something doesn't mean they don't pay attention to it; they just pay attention to it in a slightly different way than unskilled pilots. For instance, when a stick and rudder pilot climbs or descends in straight flight, he or she raises or lowers the nose to the attitude he knows from experience that will give him the desired climb or descent airspeed, respectively. Then he'll make small adjustments in attitude for precise airspeed control, all the while trimming the airplane so it doesn't wander from the desired attitude. Once done, he flies by looking over the panel at the airplane's attitude and not by looking at the airspeed indicator. While doing so, he is cognizant of the fact that his angle of attack is approximately half way between the cruise and stall angle of attack, or somewhere in the range of 11 degrees if he's using a typical climb or approach speed. He certainly isn't worried about stalling. The only thing he has to worry about is keeping his dog, lounging in the right seat, from trying to fetch the joystick every time he sees it move.

A key point to understand here is that stick and rudder pilots, contrary to what you might think, do indeed look at and use their airspeed indicator. They just don't rely on it the same way panel pilots do.

For example, a good pilot pays a little more attention to his or her airspeed indicator when taking off in a non-turbocharged airplane under high density altitude conditions. Why? The airplane's engine produces less power at higher density altitudes. As a result, the angle of the airplane's climbing flight path will be shallower than that experienced when climbing at sea level. Therefore, this pilot knows he can't place the nose in the same "relatively high" climb attitude he used when climbing under low density altitude conditions. If he did, he might stall the airplane or at least impede its climb out. And that's not what you want to experience in a Cessna 150, for example, mainly because their climb outs come pre-impeded.

Instead, a good pilot rotates to a shallower angle, sufficient to attain the desired climb airspeed (which is typically the best rate of climb speed), then makes adjustments in that attitude to maintain Vy. The point here is that the airplane's attitude is the means by which stick and rudder pilots fly, and the airspeed indicator helps them fine tune their attitude selection.

Now here's what we learned so far about angle of attack. We know that it's relatively easy to assess the angle of attack in level flight. In a straight climb or a descent, stick and rudder pilots rely more on their recollection of the appropriate attitude, but they will use their airspeed indicator to refine their attitude selection.

They also know that climbs and approaches are typically done at speeds that require an angle of attack roughly half that of the stalling angle of attack. Finally, stick and rudder pilots don't worry about their angle of attack until it approaches its critical value. And this is why these pilots have a special technique that they use to make as precise an evaluation of angle of attack possible without the use of an actual mechanical angle of attack indicator. What am I talking about? May I have some suspense music please? OK, then how about a chord or two of music. Fine, I'll just settle for a chord—specifically, your wing's chord line.

Visually Assessing Your Angle of Attack

Believe it or not, you can actually make a very good assessment of the wings' angle of attack by simply looking out your airplane's left or right window and visualizing the location of the wing's chord line in relation to the moving background. Recall that the chord line is the imaginary line running between the wing's leading and the trailing edges. By comparing the angle made between the chord line and the movement of the ground or distant horizon, you can measure the wing's angle of attack. Yes, this angle is easy to assess in straight and level flight where the horizon moves parallel to the airplane. But you can actually see this angle in a climb or descent, too. Let's call this the *wing method* of assessing your angle of attack and you just need a little calibration to learn how to use it.

Now, I don't know what caliber of person you are, so I'm going to have to get you calibrated. The next time you're in straight and level slow flight at minimum controllable airspeed, take a look at the wing's chord line. The angle between the chord line and the distant horizon is a good approximation of the wings' critical angle of attack. Under typical conditions when you're climbing at the best rate of climb speed or making your landing approach while in the traffic pattern, your angle of attack will be approximately one-half of this angle. Granted, if you're new to this method, you might have trouble assessing the angle of attack within plus or minus five degrees. But with a little practice, you'll quickly refine your ability. This is precisely why some folks to go art school, isn't it? They learn to refine their ability to judge great works of art. After a few days in art school, most folks can immediately tell the difference between the Mona Lisa and a Mona Larry and a Picasso and a potato. With a few minutes practice you'll easily be able to tell the difference between an 11 and an 18 degree angle of attack, right? That's right. If you can do that, then you can do what stick and rudder pilots do.

While making a climb or descent, all you need to do is make sure that the angle between the wing's chord line and the environment that moves past it is not close to 18 degrees. What you're looking for is something that's half that angle. If the angle is close to 18 degrees, then you'll release elevator back pressure and decrease it to about half that value, which should give you an airspeed somewhere near the airplane's best rate of climb speed. If you combine the wing method of assessing the angle of attack with the other skills I've discussed so far, you are well on your way to becoming a good stick and rudder pilot. But wait. There's more.

We've come all this way but have yet to discuss turns, which would be a turn for the worse if I didn't do something about this. So my question to you is, "How do you assess your attitude while turning?" In other words, how do you know you're not approaching the critical angle of attack when making a turn? You already know that in straight and level flight, you can make a good angle of attack assessment by evaluating the airplane's attitude above the horizon as you look over the panel. If you pulled aft too much on the elevator control, it's clear that your nose would rise in relation to the horizon and you'd clearly expect to stall. So how well does this "looking over the panel" method work when making a turn in level flight? Well, not so well.

Here's what I want you to do. Imagine that you're in a 20 degree bank turn to the right while holding altitude. Hopefully you won't lose altitude in the turn, and if you do, I'm hoping you won't pretend that you need to update the altimeter setting to correct for the difference, either.

It's clear from the 20 degree bank turn that the airplane's nose points above the horizon an amount that's close to what it was in level flight (and we'll assume that our airspeed has remained the same here). Obviously you had to apply a little back pressure to increase the angle of attack so as to compensate for the very slight decrease in the vertical component of lift in a 20 degree banked turn.

Now I want you to increase your bank angle to 45 degrees while holding altitude. Did you see what just happened? You had to increase your angle of attack to increase lift production slightly as compensation for the rather large decrease in vertical lift component. In other words, you pulled aft on the yoke a rather substantial amount as you rolled into the steep turn. Had you pulled aft the same amount while in straight flight, the nose would have shot above the horizon. Well, look at the nose position above the horizon now. It's certainly not as high as you'd think it would be given the amount of elevator back pressure you're applying. What kind of weird optical illusion is this? Or is this something that you only see when flying over the Aleutian Islands, where pilots see "optical aleutians" all the time. OK, relax. You haven't just entered the Bermuda Triangle here. Let me explain what's happening.

When you roll into a 45 degree bank turn and pull aft on the elevator to increase your angle of attack, the nose moves sideways, or horizontally, as much as it moves upward, or vertically. That's basic trigonometry and not trick-o-nometry, either. In fact, if you rolled into pure knife edge flight, pulling aft on the elevator control would result in only horizontal or sideways movement of the nose and no upward movement. The point here is that the steeper the bank angle when turning in level flight the less helpful the nose attitude is in making an immediate assessment of your angle of attack. This is why you want to use the wing method in a turn as an additional means of helping you assess the wings' angle of attack.

So, when banking steeply, glance right or left at the wing that's pointed toward the ground and examine the angle the terrain makes as it moves past that wing's chord line. This gives you and easy and quick assessment of the wing's angle of attack. If it looks anything like an 18 degree angle, then reduce the angle of attack and unload those wings. In other words, decrease your bank angle, release elevator back pressure or add power. Or do any combination of the above. This is the action that moves you further away from the critical angle of attack.

And because you've stayed with me this far, you've actually qualified for this lesson's bonus information round. While we're going to discuss stalls in next month's audio presentation, consider this. One of the most difficult issues for most pilots to understand is how their airplane can stall while the nose points below the horizon. So imagine the following.

Imagine you're in a straight, power-off descent at your typical initial approach speed. Let's say that your angle of attack is approximately 11 degrees. To maintain your present airspeed, all you need to do is keep the airplane in this same, nose down attitude. But let's make a 45 degree bank turn to the left which is the type of steep turn that pilots often make when they try to correct for a turn that will overshoot the final approach (left traffic assumed, of course). As you roll into the steep turn to the left, you find that the airplane's nose wants to drop because of the reduced vertical component of lift resulting from the turn. So you pull aft on the elevator control to keep the nose from further dropping below the horizon.

Do you see what's happening here? You've pulled back on the elevator control but, because of the steep bank, the nose moves sideways (or horizontally) only as much as it moves up (or vertically). Of course, I'm assuming a 45 degree bank is used here. You've actually increased your angle of attack a great deal but you can't sense this by looking over the airplane's nose. The nose simply didn't rise that much with the application of aft elevator pressure. So you might think that you haven't moved closer the wings' critical angle of attack when you actually have. It's simply hard to assess your angle of attack via the airplane's pitch attitude while making a descending turn.

On the other hand, it's not at all hard to assess the wing's angle of attack by using the wing method we just discussed. So take a quick peek at your wing's chord line. Does it look like you're close to the critical angle of attack? Yes? Well then unload those wings. Decrease your bank angle, release the elevator back pressure you're holding and/or add power. Yeah, don't just do something, sit there. Or not.

The wing method of assessing your angle of attack is a major tool in the skill set of a stick and rudder pilot. This is only one of many different skills that good, capable, proficient pilots have. And now you have a few new ones to add to your mental flight bag. They're yours. You only need to practice them to own them, keeping in mind that practice doesn't make perfect as much as it does make it permanent. So put this information it in your cart and checkout now to avoid checking out later, if you know what I mean.

As a final note, several years ago I gave a flight review to a fellow in a high performance single engine airplane. Immediately after liftoff, I felt the airplane yawing significantly to the left so I glanced at this person's feet. His legs were crossed and tucked under the seat as if he were meditating. I looked over at him and said, "Excuse me, Lotus Blossom, where are your feet?"

He looks over at me, points and says, "Down there."

"Where should they be?" I asked.

He replied, "Ahh, down there?"

I retorted, "No, they shouldn't be down there.

At which point I think he said, "Oh look, cheeseburger!"

I replied, "Ahh, fool me five times shame on you; fool me six times, shame on ...ohhh, I'll be right back after I check on that burger."

OK, it wasn't quite like that but the fact is that had he over-rotated on takeoff, which, for example, is a common error when departing under high density altitude conditions, he might have stalled his airplane. And stalling the airplane in a skidding condition, as he was in, means that his airplane is going to flip upside down and play dead, except in his case, it wouldn't be playing.

The point here is that he had clearly developed some very bad flying habits, which is something that can happen to every pilot. And this is why it's extremely valuable to refresh your understanding of basic flying skills. If you're scared of your airplane or you become anxious during certain maneuvers or if you feel unsure of your ability to properly control your machine, then this is most likely caused by a stick and rudder deficiency.

The fact is that the airplane will do what the pilot makes it do. And that's the intent of these lessons—to help you make the airplane obey your will in flight. So next month we'll talk about stalls and how all the things you've learned in this discussion apply to stall recognition and prevention.