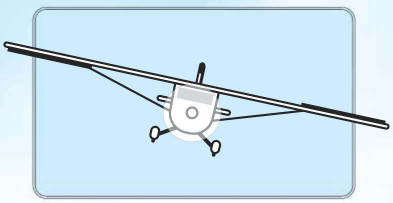
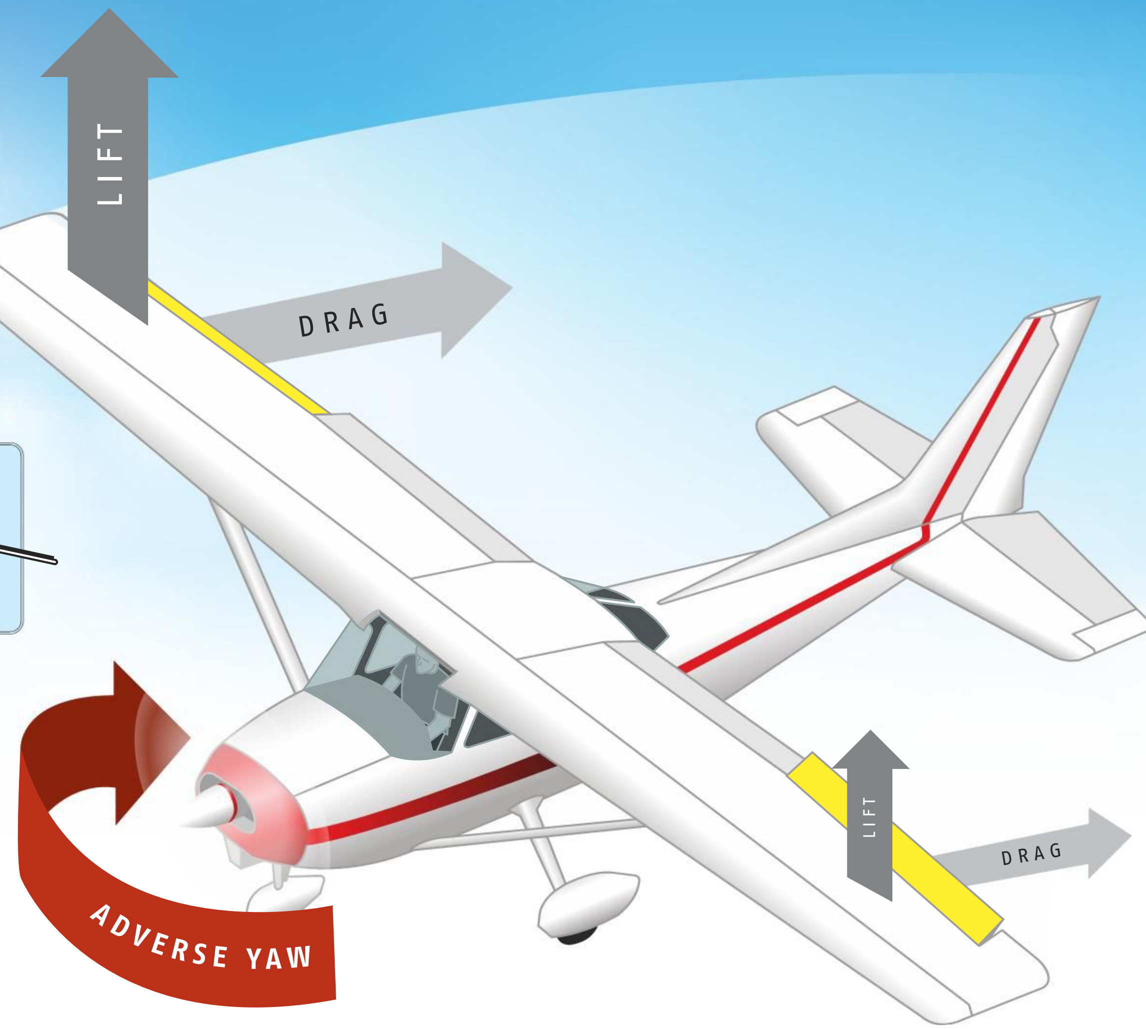


Adverse Yaw
As the airplane banks to the left, the increased drag caused by the greater lift generated by the airplane's right aileron tries to pull the nose to the right, in the opposite direction of the intended turn.



Adverse Yaw

What is it?

BY STEVE KROG

"IF YOU EVER BREAK your neck in an airplane, your ailerons will probably have much to do with it," wrote Wolfgang Langewiesche in his book *Stick and Rudder*. But what the heck does that mean?

We have experienced a good amount of nonflyable weather for the past 10 days as of writing this article, providing a lot of ground school time with students. One weak subject area encountered is knowing and understanding adverse yaw. It is not often well understood by general aviation pilots. What is it? How does it occur? What can be done to correct it? What happens if nothing is done to correct it?

First, let's define yaw. According to the Merriam-Webster online dictionary, yaw can be explained as a side-to-side movement or, specific to aviation, to turn by angular motion about the vertical axis. Adverse yaw is the tendency for the nose of an airplane to yaw in the opposite direction when an airplane banks its wings for a turn. The increased lift of the raised wing results in increased drag, which causes the airplane to yaw or swing toward the side or direction of the raised wing. The rudder is typically used to counteract adverse yaw.

If uncorrected while in normal flight, safety is not usually affected — but it can lead to a more serious situation. Rather, it generally creates inefficiency in flight and possibly physical discomfort among passengers as the aircraft skids and slips from side to side while conducting uncoordinated turns.

ILLUSTRATION BY BRANDON JACOBS

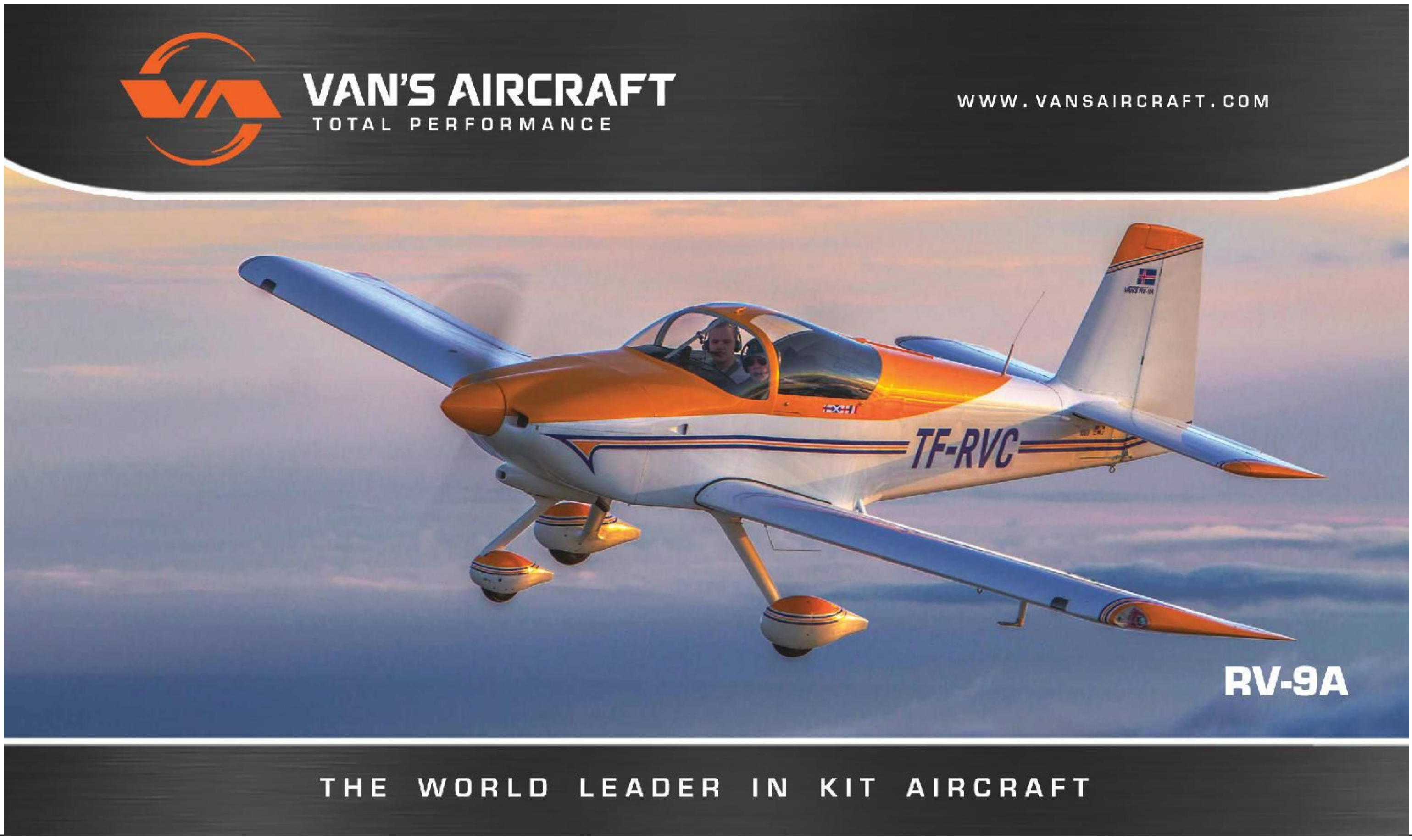
WHEN DOES ADVERSE YAW OCCUR?

Adverse yaw can occur in many situations but is most often experienced when making a turn while in flight. For instance, when a pilot initiates a turn to the left, the yoke or control stick is rotated or moved leftward. That causes the left aileron to rise upward, pushing the left wing down. While this is occurring, simultaneously the right aileron travels downward, generating more lift and forcing the right wing upward. Generating more lift also generates more drag, so in this left turn, the right wing pulls or "drags" the upward wing away from the direction of the turn. That causes the nose to move or yaw to the right before turning left. This is adverse yaw.

The yaw is most evident in slower airplanes with long wings, like J-3 Cubs, Taylorcrafts, Aeroncas, and Cessna trainers. Many aircraft manufacturers later designed the ailerons to help offset the yaw, but the primary control for efficiently managing the yaw continues to be the rudder.

Adverse yaw is the tendency for the nose of an airplane to yaw in the opposite direction when an airplane banks its wings for a turn. The increased lift of the raised wing results in increased drag, which causes the airplane to yaw or swing toward the side or direction of the raised wing.

Some students, as well as pilots, have a difficult time recognizing adverse yaw. When this occurs, I demonstrate it by establishing straight and level flight at a speed somewhat slower than the normal cruising speed. The slower the aircraft is flying, the more pronounced the yaw. Rotate the control yoke to the left or move the control stick to the left, establishing a banking left turn. Do not make any rudder inputs. As the right wing rises, the nose will move or yaw to the right in a rather pronounced movement before finally moving to the left. Return to level flight using ailerons only, and the yaw is again clearly visible. Now try a turn to the right without adequate rudder and watch the nose move to the left or away from the turn. The adverse yaw is quite pronounced.



WHERE DOES ADVERSE YAW OCCUR?

Most flight training manuals explain adverse yaw by describing banking turns as mentioned above. However, it can occur in several other flight attitudes, some quite critical.

A crosswind takeoff creates adverse yaw for instance, but it is not usually recognized by most pilots. When setting up for a crosswind takeoff with a wind from left to right, the control stick is positioned to a full left deflection. The left aileron is deflected full up to prevent the left wing from flying before the right wing. The right aileron is full down, creating increased lift — but also more drag. As groundspeed increases during the takeoff roll, the right wing is actually helping the aircraft remain aligned with the centerline by creating both lift and drag. But the aileron does not create enough drag to offset the crosswind, nor the engine torque and propeller P-factor being generated to keep the airplane moving straight down the runway. In this example, right rudder must also be applied to help maintain directional control.

In a common crosswind, as groundspeed increases the ailerons become increasingly more effective. Less aileron correction is needed to keep one wing from flying before the other. The lesser the down aileron, the lesser adverse yaw is being created. Just at the instant of liftoff, the ailerons should be moved to the neutral position to eliminate the adverse yaw.

Climbing turns create adverse yaw, especially when making right turns. But is it critical? Usually not, but it does create inefficiency and a lack of good coordinated control inputs.

ADVERSE YAW IN THE TRAFFIC PATTERN

As a flight instructor, one area in which I observe adverse yaw situations is in the traffic pattern in preparation for landing. When abeam the runway numbers on the downwind leg, power is reduced to begin slowing the aircraft. Remember practicing slow flight? The slower the airspeed, the more sluggish the controls, which then require more input.

Initiating the descending left turn onto the base leg at this slower airspeed requires a fair amount of left stick movement. Frequently, the pilot does not match the increased aileron input with coordinated left rudder input. For the first few seconds, the airplane is in a significant adverse yaw situation with the nose moving to the right while the airplane is trying to turn left. Slowly the nose begins to follow the rest of the airplane and sluggishly turns left. About halfway through the turn, the aircraft stabilizes, completing the turn. At the point of rollout leveling the wings on the base leg, increased right stick needs to be applied. Again, the extra right rudder input is seldom applied. The aircraft is again placed in an adverse yaw situation as the airplane turns right but the nose moves leftward. This situation has become a bit more critical because the airspeed has properly been reduced.

Some students, as well as pilots, have a difficult time recognizing adverse yaw. When this occurs, I demonstrate it by establishing straight and level flight at a speed somewhat slower than the normal cruising speed. The slower the aircraft is flying, the more pronounced the yaw.

Finally, at yet a slower speed, the aircraft banks left onto the final approach leg aligning with the runway in preparation for the landing. In most light aircraft, the airspeed has been reduced another 10 mph, making aileron and rudder inputs even more sluggish. When the left turn onto final is initiated, significant left stick movement and left rudder application are again needed for the coordinated turn. However, that is often not what I observe. Rather, the proper aileron inputs are made but not the rudder. Again, the aircraft is now in an adverse yaw configuration and at a slow airspeed. Safety is now compromised, especially if the pilot allows the nose to pitch upward. The aircraft is in a near cross-control configuration. This is the critical area where stalls and stall/spins can occur.

Coordinated aileron and rudder inputs will eliminate a good portion of this critical situation, preventing adverse yaw. However, a second critical situation is often created if the pilot overshoots the runway on the turn to final. Rather than realigning using coordinated aileron and rudder, the controls are cross-controlled. Hard left rudder is applied in an attempt to bring the aircraft back in the line with the runway centerline, but right aileron is also being applied so as not to create a steep bank. This configuration can be quite safe if attempting to perform a slip and the pilot knows how to execute it properly. However, this uncoordinated situation is a step toward disaster. Cross-controlling unintentionally causes the nose to pitch upward and the airspeed to dissipate. The aircraft is now in a more critical stall or stall/spin configuration while close to the ground.

An astute pilot will be aware of the control input needs and fly the airplane in a coordinated manner. A lackadaisical pilot will be oblivious to the added inputs needed when the aircraft is flown at a slower airspeed, creating the adverse yaw situations I've described. This compromises safety for both the pilot and the passengers enjoying a flight in a small general aviation aircraft.

Be aware, practice good coordination, and fly safely so that you can enjoy a flight again on another day. *EAA*

Steve Krog, EAA 173799, has been flying for more than four decades and giving tailwheel instruction for nearly as long. In 2006 he launched Cub Air Flight, a flight-training school using tailwheel aircraft for all primary training.