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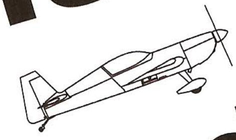
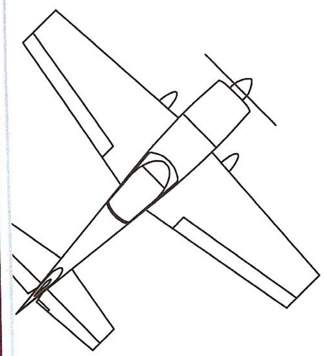
Hammer Spins Revisited



After reading Rich Stowell's excellent article on the subject of spins and hammerheads (*Advanced Spin Training*, May/2010), I thought I would weigh in with some of my own experiences on the matter. This discussion also highlights some of the confusion that exists regarding spins and spin recoveries in aerobatic airplanes . . .

BY BEN FREELOVE



I LIKE TO THINK there are no "nasty" spins in modern aerobatic aircraft, especially the Pitts. The so-called "rogue" spin is a completely mythical tale, and classifying any spin as more hazardous than another can breed fear and lack of confidence in our ability to recover. This fear may create a psychological "survival" response, which will impede a pilot's ability to properly recover. There are most certainly spins in our aircraft that are more intense to ride through than others, but it must be understood that this intensity is merely our perception of the spin and does not change our recovery technique. An airplane only spins in response to a specific aerodynamic condition, and the beauty of most current aerobatic models (Pitts, Extra, etc.) is that the pilot can use a universal recovery technique that applies to all spin modes. One of the reasons to attend an advanced spin recovery course (a must for any solo aerobatic flight) is to experience all of the spin scenarios the airplane can produce, most importantly those spins that are very intense *feeling*. With just a little practice we can desensitize to the physical sensation of the spin and teach ourselves to react calmly and methodically while applying our recovery procedure in response to visual cues alone.

Hammerhead

The hammerhead is a beautiful and engaging maneuver—which if flown well, demonstrates mastery of our craft. Despite its other common name—the stall turn—the wings fly through the pivot at zero angle of attack. Zero angle of attack is furthest from both the positive and negative critical angles of attack. It would seem this figure is an unlikely candidate to develop into a spin, albeit a confusing one. But once we consider gravity, and the lowered stability at the apex of the vertical, even a slightly botched pivot can deviate into some disorienting situations. Let's examine a couple potential scenarios to see how the plane and pilot might react, as well as the proper steps for a successful recovery.

The following two scenarios are based on common hammerhead mistakes that can

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happen even to experienced aerobatic pilots. Because these situations can lead to confusing spins, few people truly recognize what is actually occurring, and the subtlety of the dynamics can be tricky to figure out. It took witnessing a significant amount of these spins and a lot of discussion with other instructors for me to gain a solid understanding of how this situation to occurs.

Pivoting Too Late

For now, let's not worry about proper timing of the turnaround. For this scenario let's just assume we've kicked too late. You may want to grab a small model to follow along with this analysis in order to visualize what is happening. (See Fig. 1)

Yaw—As we apply full rudder (left rudder with Lycoming engines), the airplane begins to yaw abruptly toward the horizon.

Roll—Because we are at a slow airspeed and are most likely sliding at this point, the ailerons have lost most of their effectiveness to counteract the torque (left rolling force) from the engine/prop. We've all "torqued" out of hammerheads and can relate to what this looks like.

Slide—The effect of gravity is such that it applies a downward force on the airplane, causing it to slide during a late pivot.

Let's put these forces together and see what happens. As the yaw tracks the nose through the horizon, the torque rolls the airplane inverted, and its downward inertia places a negative angle of attack on the wings. The typical forward elevator position during the pivot actually increases this negative angle of attack. This causes the wings to stall, which is the first ingredient for our spin.

Pivoting Too Early

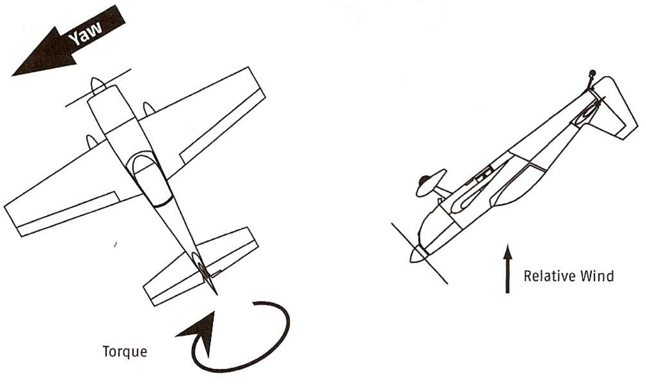
Before we look at the end result of the above setup, let's examine our "kicking too early" scenario since it places the aircraft in essentially the same attitude as described above. (See Fig. 2)

Yaw—The pivot happens as before: full rudder and aggressive yaw. However, since the airplane still carries some forward airspeed, the yaw rate will become damped. This damping dramatically slows the rate of yaw, placing the airplane in an upward tracking sideslip.

Yaw—Pitch Coupling

Once in this left sideslip condition, the prop begins to produce asymmetric thrust that

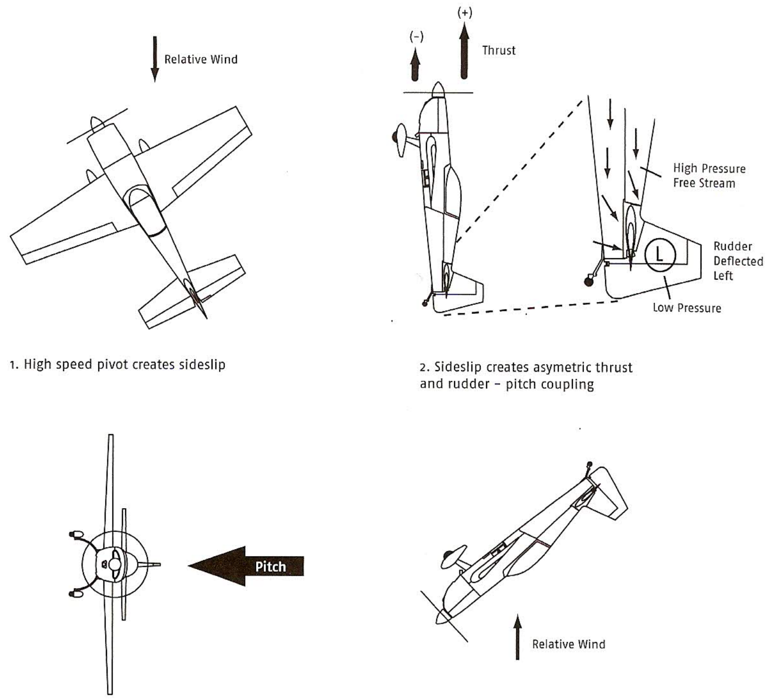
Figure 1. Low Speed Pivot Dynamics



1. Torque and Yaw during the pivot

2. Combined effects of Torque and Yaw leave the aircraft in a high negative angle of attack descent

Figure 2. High Speed Pivot Dynamics



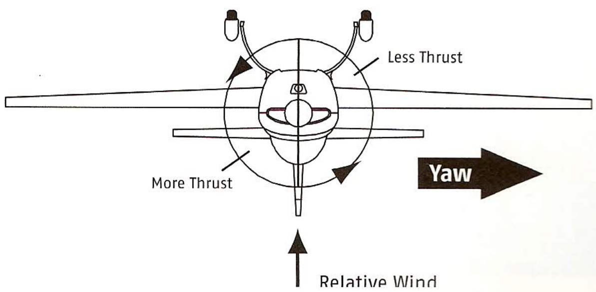
1. High speed pivot creates sideslip

2. Sideslip creates asymetric thrust and rudder - pitch coupling

3. Aircraft pitches toward the gear as the pivot continues

4. Aircraft is placed in high negative angle of attack descent

Figure 3. Asymetric Thrust



See a video demonstration of these maneuvers by visiting this YouTube link: http://www.youtube.com/user/tutimaacademy

creates a pitching moment toward the landing gear. Furthermore, when full left rudder is deflected for the pivot, the low pressure created on the "working side" of the vertical tail changes the angle of attack of the horizontal stabilizer. This creates an additional nose-down pitching force.[1] These two forces coupled with our mechanical application of forward stick, pitch the airplane on its back. As the slow pivot continues, gravity pulls the airplane downward. This produces a large negative angle of attack, triggering the stall.

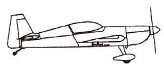
End Result

Both of our mistimed pivot scenarios have placed the airplane in the same condition—sinking inverted, with full power—let's look at how both the pilot and the airplane react to this condition.

As the wings begin to stall, the airplane accelerates its descent rate, which creates a relative wind perpendicular to the propeller disc from below (as viewed from the ground). This airflow generates asymmetric thrust. With a Lycoming engine at a high negative angle of attack, this is a powerful right yawing force. (See Fig. 3)

Imagine now what our pilot is experiencing. As the nose moves away from the intended flight path, the anticipated sight picture begins to break down. A common response to this confusing new configuration is to relax the pressures on the flight controls. This includes the rudder, which was being held full left for the hammerhead pivot.

Once the rudder is relaxed, the asymmetric thrust is ready to take over, drive the nose hard to the right (even with some left rudder still applied), and a clean entry to an inverted flat spin has just occurred. This inverted spin is right yawing and left rolling, which is counter-intuitive. Most would assume that because of the left rudder used for the pivot a left yawing, right rolling spin would occur. The force from the asymmetric thrust in this case can simply overpower the inputs from the pilot. It's interesting to note that the asymmetric thrust in the Pitts can often produce a very strong right yawing moment, even against full left rudder!



Both of our mistimed pivot scenarios have placed the airplane in the same condition—sinking inverted, with full power.

At this point the pilot recognizes the spin, is ready to recover, and begins to go through the spin recovery procedure: *power idle, full opposite rudder, stick neutral*. Pulling the throttle to idle will diminish the asymmetric thrust, and the rate of yaw will begin to slow somewhat. However, instead of using the correct procedure

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and *looking* over the nose to determine the direction of the yaw, the pilot simply mechanically switches their rudder input from left to right! This is an unfortunate muscle memory habit we form as we learn to recover from spins initiated on purpose. Another reason right rudder may be applied is that we always use brief full right rudder to finish our hammerhead pivot.

Switching to the right, the rudder now becomes pro yaw, and placing the stick neutral "steepens" the spin, which increases the rate of rolling rotation. The spin is of course not stopping, and our pilot is now fully confused. In a state of panic one of two evolved psychological responses will happen, fight or flight. The pilot either simply continues to hold whatever inputs he has (flight), locking up on the controls with the incorrect rudder depressed, or he "churns butter" (fight), frantically trying various inputs in hopes he might stop the spin.

The correct response is to relax, admit you are confused, and start the recovery procedure over from the beginning in a calm, methodical fashion. Verify the power is actually at idle (tug firmly on the handle). Look directly over the nose and identify the direction of the yaw. This takes practice: you need to be desensitized to these intense *feeling* spins with proper training to be able to confidently determine which rudder to use.Apply deliberate, quick, full opposite rudder to the yaw. Verify the stick is neutral (no elevator, no aileron). Look down if necessary or simply let go of the stick if you prefer the hands-off technique. Once the rotation has stopped, neutralize all the controls (don't forget the rudder), pull out of the descent while applying full power for minimum altitude loss. Pull the nose all the way through the horizon and verify the airplane is climbing.

One interesting side note to the above scenario is that this can transpire even if full controls are held during the entry. Aerobatic airplanes (especially the Pitts) can readily spin against both the rudder and elevator. I have many, many times been in spins that are rotating opposite the rudder held and/or at a loading that is opposite the elevator position. This can easily lead to the confusion described above, and it's my belief that is what leads to improper recovery and the legends of rogue spins. If a pilot is not well-versed in the fundamentals of spin recovery technique, it is unlikely they will use the correct procedure. It is important to note that recognizing the type/mode of spin and how you got there is completely irrelevant to the recovery! Again, the solution is to get in-depth training in all spin modes and insist the instructor show you some of the more confusing scenarios. If the instructor is unfamiliar with how to demonstrate these, find someone who can. Practice high and fly safely. IAC

*Editor's Note: For a good explanation of asymmetric thrust and rudder induced pitch-coupling see (*Endo Tumble, *September 2009)*